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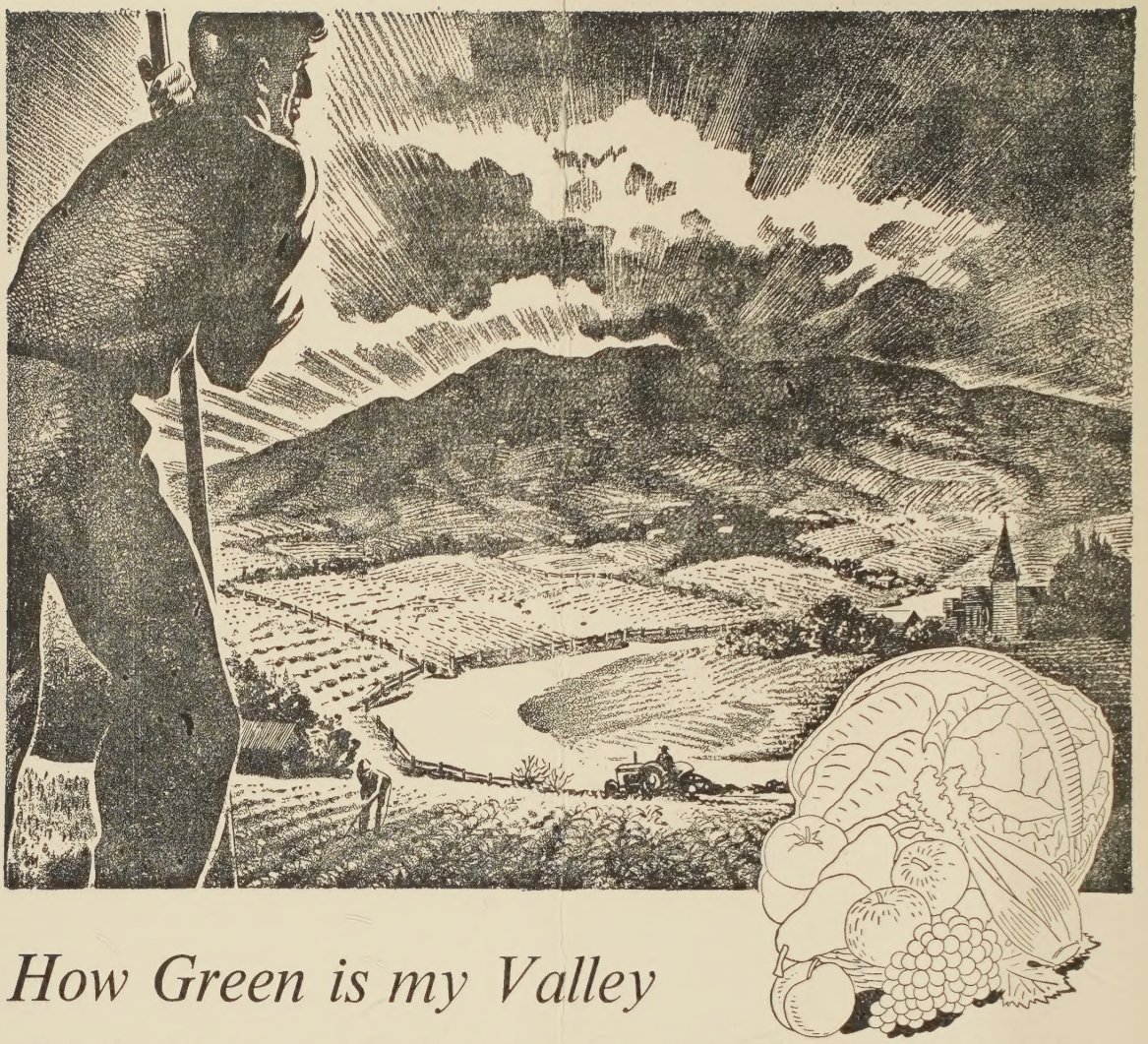

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Vol. 20 **No. 4**

DECEMBER, 1954

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ARTICLES

THE FARMERS' ANGLE ON AGRICULTURAL EXPANSION

By W. A. GUNN

The purpose of this paper is to examine the attitude of the producer himself towards increased production of food and fibres.

In general terms it can be said, firstly, that the majority of farmers consider themselves obliged to make the best use of their land and to expand production if practicable, and secondly, that most farmers desire to expand production provided they are reasonably sure that this will prove profitable in the long run.

When deciding whether a programme of development and expansion is practicable and potentially profitable on an individual farm, a number of factors must be taken into consideration. Each of these factors is analysed below.

Markets and Prices

Developmental expenditure is usually of a long-term nature and many years elapse before it is recouped. Hence market prospects not only for the immediate future but also for years ahead, are a major consideration. Market prospects for the various forms of primary produce are briefly discussed below.

Beef

For the year ending June 30, 1953, the production of beef and veal reached the record quantity of 674,000 tons. Cattle numbers have increased and a further increase in beef production is likely in the near future, but the demand is continually increasing and this would seem to ensure a satisfactory market.

Although consumption per head in Australia is still below pre-war levels, the increase in population has resulted in higher total home consumption, the local market absorbing about three-quarters of total production.

For the remaining quarter we have the United Kingdom market, since under the terms of the Fifteen Year Meat Agreement the U.K. is obliged to provide a satisfactory market for all our exportable surplus of meat.

The U.K. Government has announced its intention to decontrol the meat trade this year. Beef producers are confident that the United Kingdom will still provide a good market, as it is estimated that she will be deficient by about 400,000 tons on her pre-war consumption of meat.

Mutton and Lamb

Without the Meat Agreement the prospects for mutton are not good. It cannot compete on a quality basis with other meats and, in the markets to which Australian mutton is sent, consumers can afford to buy lamb or beef.

High wool prices have had the effect of keeping sheep in wool production to an older age than previously and the stocks of old mutton which have resulted, are depressing the market. Only in the event of a marked fall in wool prices,

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causing sheep to be slaughtered at an earlier age, would the position for mutton improve.

With lamb, the position is much the same as beef, in that nearly three-quarters of the supply is consumed by the local market. This is a direct reversal of the pre-war situation.

Providing quality is right, we should be able to find markets overseas for any surplus of lamb which might develop in this country, as the result of increased output.

Wool

The market prospects for wool are quite satisfactory although predictions in this sphere are likely to be confounded at any time by changes in unknown factors. All that we can do is to look at the statistical position of wool and relate it to prices in recent seasons. Despite the ever-increasing volume of wool production all the available offerings are being taken up at good average prices and there is nothing to suggest any change in the factors operating on the market.

The 1952-53 and 1953-54 seasons have been ideal from the producers' point of view—attractive, stable, average prices. The expectations of woolgrowers are that such a market will remain with us and organised woolgrowers of the Commonwealth are actively campaigning for increased wool production.

Wheat

The present statistical position is not good for wheat exporters. This is primarily because the U.S. price-support policy, aided by a run of good seasons in North America, has resulted in too much high-cost American wheat. The position is being aggravated by U.K. and other importer countries who are drawing on stocks, with an apparent immediate objective of "cracking" the wheat market. But, in the longer term, authorities tell us that the main point is that Australia is a low-cost producer by comparison with America. She is, moreover, the only significant supplier of sterling wheat. Whilst U.K. and other importers are entitled to, and have a lot to gain, in bringing prices down from the £1-per-bushel level, prices which would depress Australian production would react against the U.K. and the sterling area on the long term. The world is already dependent upon Canada and the U.S.A. for more than two-thirds of the world wheat trade, and dollar wheat is not cheap wheat. The sterling area cannot afford to have to rely even more on North America.

For these reasons, the immediate wheat marketing difficulties should not cause us to lose sight of the longer-term prospects which are sufficiently encouraging to justify an expansion of wheat production.

The Contribution of Research and Extension

During the last 20 years or so there has been a marked change in the attitude of farmers towards the scientist. Most of them are now willing and anxious to hear the results of research, to receive scientific advice and to put such advice into practice. However, the fact that farmers are anxious to adopt improved methods does not ensure that this will be done, and there remains far too wide a gap between research developments and their commercial application on the general run of farms.

There is real need for enough technically trained officers to visit farms regularly and discuss, on the spot, detailed plans for development and the economics of their application. This last point is important. The farmer will only go ahead if he is satisfied that it will pay him to do so. Usually there are one or two progressive farmers in each district who are regarded as "guinea pigs" by their neighbours. Their successful experiments are usually taken up after some time lag. To hasten this evolutionary acceptance of advanced techniques,

the extension officer must be able to demonstrate in advance that their application will be profitable. Besides training in farm economics, farm management and the use of farm budgets, the extension officer needs the backing of much more economic research into such matters, so that he has facts and figures at his disposal to provide convincing evidence that practices which he advocates will pay.

The two most important requirements are material ones, namely, general expansion of the extension services and also establishment of special financial institutions for the provision of capital for developmental purposes. Subsequent to the agreement of all the Australian Governments that expansion of food production should be given the highest priority, the Commonwealth Government contributed special funds towards expanding State Extension Services, but there is still a clear need for the States themselves to make more money available.

It is high time primary producers themselves contributed towards the expansion of extension services, as such development is vitally necessary to their continued well-being. For the primary producer costs of production are largely outside his control. His main opportunity to get his costs down is to increase his efficiency of production through the introduction of new techniques and the application of the results of research. He can best do this through the advice of extension officers.

The Wool Industry contributes nearly £800,000 per annum toward Wool Use Promotion and the Commonwealth matches this to the extent of ten shillings in the pound to finance wool research and the application of the results of that research. Certain other industries make relatively minor contributions to research through their marketing boards, but all industries could contribute very much more, and it would be to their own advantage to do so. Not only would they receive the benefits of improved extension services, but by their direct association they would be entitled to a voice in the general policy and planning of extension work, and liaison in this regard would increase the efficiency of this work.

Availability of Labour, Materials and Equipment

Shortages of these resources retarded development during the early post-war years and have only been alleviated to any great extent during the last year or two. It has been a continued source of amazement to primary producers that Governments could have been so preoccupied with the encouragement of secondary industries that primary industries could be left for years to battle on with entirely inadequate supplies of materials such as fencing, piping and galvanised iron and of machinery, such as harvesters and ploughs. At a time when the Australian manufacturing capacity for farm equipment has been totally inadequate, many manufacturers have appeared before the Tariff Board with applications for protection to allow them to engage in much more complicated and therefore costly manufacture, and, of course, the luxury industries flourished.

Credit

Large amounts of capital are required for any worthwhile developmental project. To fence and water open range country adequately, costs about £10 to £12 per beast area, or £100,000 or more for a 10,000 herd proposition; this would represent quite a small property in inland northern areas. It probably costs more that £10,000 to clear and equip a "living area" for wheat production in Queensland. It would cost considerably more than this to develop a thousand acres of the "wet desert" country in the south-east of South Australia for sheep and lamb production. During recent prosperous times it has been possible for farmers and graziers to finance a great deal of developmental expenditure from

their own resources and current earnings.

Taxation concessions introduced a year or so ago have been a major incentive and it is considered that this is one of the major factors in the recent notable increase in production. These taxation concessions enable all developmental expenditure, even of a capital nature, to be deducted from taxation returns within five years. In the case of a producer in a high income group, paying, say, twelve shillings in the pound, a programme of development over a number of years would cost him only eight shillings in the pound on his improvements. A tremendous stimulation of private investment in rural production has resulted from this enlightened taxation policy, as a result of which farmers who have availed themselves of it have well developed and productive properties and a prosperous future in front of them.

Because sums involved are large, not all development can be financed from current earnings, and adequate and generous credit is essential to the food production programme. Total Bank advances to the rural sector have increased from £109*m.* in 1949 to £148*m.* in 1953—much less than the decline in the value of the pound. Over the same period the increase in *total* Bank advances was from £429*m.* to £670*m.*, the proportion of rural advances declining from 25.4 per cent. to 22.1 per cent., which suggests that either farmers did not require further accommodation or that they could not obtain their requirement.

It is considered that development is being retarded in many cases through inadequate credit being available from ordinary banking institutions. Also, special arrangements are necessary to provide flexible finance for the peculiar needs of rapid expansion in our capacity to produce more food and fibres.

An instance of the need for more attention to be given by Governments to the question of provision of adequate financial facilities is the operation of closer settlement policy. Closer settlement will not succeed unless substantial funds for capital development are put into the hands of new settlers, who are invariably battling for finance. One would expect this to be obvious to those concerned with the promotion of such schemes. In this regard a very good example of failure is the brigalow and belah areas of Queensland which were thrown open for settlement after *Cactoblastis* had destroyed the prickly pear. Settlers were put on this land with no capital other than a big heart and a pair of hands, and for the best part of ten years very little development took place. Now after approximately 18 years these lands are again being sub-divided and the undeveloped areas will be available for selection. Unless the new settlers who take up these lands are given substantial funds for development, they will not be able to participate in the spectacular improvements which are taking place in these areas.

Governmental Works Programmes

One cannot expect prosperous and expanding rural industries unless private development is supported with public expenditure on developmental works, services and facilities. It is in this field that recent endeavours have been most inadequate.

Between 1946 and 1949, national public expenditure on irrigation, forestry and land development ranged from £7 *m.* to £12*m.* out of a total public investment of from £91*m.* to £154*m.* Expenditure on the rural sector (which, of course, does not cover roads, education and other rural services) amounted to 7.8 per cent. of total public investment. In 1952/53, however, expenditure on rural works was only £22*m.* against a total public investment of £397*m.* or only 5.5 per cent. of the total. This is shown in Table I. This situation is undoubtedly holding up our food production programme.

TABLE I.

Public Investment in New Works and Maintenance.

Year	Irrigation, Forestry and Land Development		Total Public Investment
	£m.	As % of total	£m.
1946/47 ..	7	7.7	91
1947/48 ..	9	7.6	118
1948/49 ..	12	7.8	154
1949/50 ..	17	7.8	218
1950/51 ..	21	6.9	306
1951/52 ..	30	7.3	410
1952/53 ..	22	5.5	397

Source: National Income and Expenditure, White Paper, 1952/53.

Apart from a totally inadequate scale of effort there has also been faulty planning in Government works, with resources spread too thinly over too many projects. There is a clear need for concentrating to enable completion of highest priority works and for selectivity in initiating new works. As an example it is appropriate to consider the question of transport which has become the main limiting factor in development of the cattle industry of the north. A railway from Dajarra to Newcastle Waters is essential if the potential of the breeding country of the Northern Territory and the fattening country of Queensland is to be used effectively. Such a railway would cost about £20*m.* and would enable an increase in beef production worth more than £4*m.* per annum, apart from other benefits. This in itself would warrant priority for the expenditure, but far more important is the fact that provision of access to market would make economic the fencing and watering of the open range country right across the Territory and would stimulate private investment for this purpose of perhaps an equivalent amount. Government and private investment must go hand in hand if we really want to achieve the food production programme.

Conclusion

In summary therefore, it is considered that although fair progress has been made on our food and fibre production programme, it is possible to produce still more and, moreover, farmers are willing and anxious to play their part. Prerequisites for the successful achievement of our economic potential are:—

(1) Satisfactory and stable markets for the products to be expanded.

(2) More research, and particularly more extension work towards which farmers as well as Governments should contribute,

(3) Government policies designed to ensure the availability of resources for rural development,

(4) Adequate credit facilities designed to meet the special needs of rural development and

(5) Governmental works programmes which will support and stimulate private investment in country areas.

SOME SOIL FACTORS AFFECTING QUALITY IN AUSTRALIAN FLUE-CURED TOBACCO

By A. V. HILL

The 10 to 15 years following the end of the first World War were notable for the difficulties experienced by tobacco growers and the numerous committees of enquiry that prepared voluminous reports on the Industry. The major change from air-cured to flue-cured production disturbed the previous pattern of production to such an extent that whole districts abandoned tobacco. In others it was restricted to particular localities and also, entirely new producing districts were established. The basic reason for the change was that soils high in available nitrogen, as used for the production of leaf for air curing, were not capable of producing leaf suitable for flue-curing.

The present trend toward increased consumption of factory made cigarettes has resulted in a greater demand for thin, bright leaf and growers are trying to meet this demand by producing a greater proportion of such leaf. This, together with an increase in the number of growers and an extension in the area cultivated, has resulted in increased production.

To those familiar with the development of tobacco production in Australia during the last 30 years, any factor likely to encourage rapid expansion raises the possibility of another period of crisis, similar to that of 1932-34, when the area planted increased and quality deteriorated. Then there were two main factors affecting production — unsuitable soil and blue mould disease. Both still exist, but the influence of blue mould has been reduced by planting disease-free seedlings from benzol treated seedbeds and the more experienced growers have a better understanding of soil requirements. This progress was made at considerable cost and some of the lessons learned may, with profit, be brought together for the information of those who have become interested in tobacco production since that time. Particular attention will be given to the effect of soil on leaf quality.

Suitability of Leaf for Flue-Curing

The necessity for low available soil nitrogen in flue-cured tobacco production was established many years ago. Subsequently, chemists showed that good flue-cured tobacco contains plenty of sugars and other carbohydrates and that air-cured tobaccos have almost none. Thus flue-cured leaf is sometimes referred to as "sweet", good smoking tobacco. Nitrogen content of the leaf before harvesting is of great importance, because it exerts a controlling effect on carbohydrate content which "in mature tobacco leaves varies between 20 and 50 per cent. of dry weight according to the type of tobacco" (Weiss 1950). This author also quotes for the better grades of flue and air cured tobaccos respectively, total nitrogen at 2.00 and 3.43 per cent. while sugars are 18.75 and 0.50 per cent.

The suitability of a soil for flue-cured production is often assessed on the basis of texture but this is applicable mainly in so far as heavy soils are high, and light soils are low, in available nitrogen. Application of nitrogen to light soils could make the plants grown on them entirely unsuitable for flue curing. Referring to a soil initially low in nitrogen

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Swanback (1952) states that "Nitrogen is deposited in the leaf somewhat in proportion to nitrogen supplied in the soil". In other words, nitrogen availability is a determining factor in nitrogen accumulation in the leaf.

Leaf high in nitrogen whether grown on light or heavy soil is not suitable for flue curing even though it comes from a flue-curing variety. Such leaf, whether air or flue cured, is unacceptable to manufacturers in Australia yet is still produced to a limited extent especially when top leaves are flue-cured.

Thus if top leaves of plants that have already produced good flue-cured tobacco have a high nitrogen content they should not be flue-cured. The importance of nitrogen nutrition in flue-cured tobacco production on soils naturally low in nitrogen is shown in numerous publications, many of which are listed by Garner (1951).

If nitrogen supply is too low, as shown by early onset and persistence of nitrogen deficiency symptoms, carbohydrate content may be too high. Weiss (1950) lists the lower permissible limit for total nitrogen and the upper optimum limit for sugars in flue-cured cigarette tobaccos as 1.35 per cent. and 26.00 per cent. respectively. Extremes may occur to a much greater extent than is generally realised.

Soil Organic Matter and Leaf Quality

In overseas publications there is an insistence that flue-cured tobacco must not be grown immediately after leguminous crops and that crops supplying an extra large amount of organic matter and nitrogen should not precede tobacco unless the material has had time to rot after being ploughed in. Such land is stated by Moss and Bullock (1938) to be in "too high a state of fertility". These authorities also state that "The rotation practised will influence the character of tobacco produced probably as much as the fertiliser used" and that unbalanced mineral nutrition can result in an "abnormally large leaf growth".

As clovers or other legumes are common in most tobacco areas in Australia these warnings are of particular significance to our growers. Expansion in production often involves utilisation of areas under legumes or with large amounts of organic matter either in or on the soil. Tobacco plants on such soils are tall, with large soft leaves and they seldom produce a high proportion of good quality leaf. Sometimes the whole crop is worthless. This condition has been observed repeatedly in all areas during the past 25 years. In some, e.g., Victoria, poor leaf is accepted as a temporary but normal consequence of cropping pasture land, while in others, e.g., North Queensland, it tends to be regarded as part of the normal crop loss. In the early years of the Mareeba-Dimbulah area, in the lower Burdekin Valley in recent years, and in all areas during the present period of expansion, an excessive quantity of thin worthless leaf has been produced. Such leaf may be described as thin cigarette type leaf that fails to retain the yellow colour when cured. It becomes papery, brown, worthless tissue that will not "condition" but shatters in handling. Leaves less severely affected may be partly yellow and partly brown and have some value. Its smoking quality is not good but the very objectionable characteristics due to high nitrogen in leaf that should not have been flue cured are not present.

Tobacco leaf with these general characteristics is classified by the trade as "trashy". In U.S.A. nomenclature the nondescript group of grades includes trashy thus—"The common-quality lugs may carry dingy and a few burnt and trashy leaves . . ." (Taylor 1940). This thin, papery leaf provides a distinct contrast with the thick, dingy or dark, harsh or leathery leaf with high nitrogen content.

Some of the chemical characteristics of trashy leaf were determined by Johanson (1951), the material being from Clare, Queensland. Material of the same type could have been obtained from any of the other tobacco growing areas in Australia. His values for nitrogen content, on a dry weight basis, are similar to those for good flue-cured leaf while carbohydrate content is *very low* as is also the dry weight per unit area. Thus the weight of trashy or partly trashy leaves is much lower than that of an equivalent number of good leaves. A somewhat similar leaf condition occurs in Italy where Ciferri (1953) found low glucide, potash and calcium contents and where Bolli (1953) concluded from other investigations that excessive soil fertility resulted in lack of normal maturity due to retention of water by leaf colloids.

The loss, in terms of good leaf, is hard to estimate. In North Queensland in 1933 it was probably more than 60 per cent. of the total crop (Tobacco Inquiry Committee 1933). In subsequent years individual losses of more than 80 per cent. have been observed repeatedly in various areas. The annual average loss, particularly in Queensland, could be of the order of 20 per cent. by weight of the leaf sold.

Plant and Leaf Characteristics

Plants that may be expected to produce trashy leaf on flue-curing are tall, with large thin leaves that may not become the light-green colour associated with normal ripening. The lowest third of the plant is most commonly affected, and there is often a gradual reduction in severity from the lower to the upper part of the plant. This may be due, in part, to the effects of shade in crops of large succulent plants, and to inability of leaves to synthesize and retain normal cell constituents. The plants are described by growers as "too growthy" or "too rank" or as plants that "keep on growing and never stop to ripen". Affected leaves cannot always be detected with certainty in the field and early curing behaviour is not markedly abnormal but the yellow colour is lost very rapidly with increase in barn temperature.

Whatever the basic cause the evidence so far available suggests that an explanation may be found in the theories developed by Kraus and Kraybill, as summarised by Miller (1938), on the carbohydrate-nitrogen ratio and the changes in this ratio with maturity. Thus, in potentially trashy leaf, the vegetative phase of growth with its low C/N ratio tends to persist and high C/N ratios characteristic of the reproductive phase do not develop. From existing information it may be postulated that an inverse correlation occurs between the rate of plant growth, particularly at the time leaves are picked, and the quality of those leaves when flue-cured; this may be a profitable basis for physiological investigations.

Conditions Unfavourable for Good Leaf

In southern Australia growers expect trashy leaf in crops on newly ploughed pasture land especially if clover was present. The third crop in as many seasons, is expected to produce good leaf. Soil conditions favouring trashiness are therefore temporary, and are not likely to develop between seasons because of the very limited growth during the cold winter months.

In northern areas the association between soil and trashiness is not clearly evident, even though seasonal conditions and cultural practices may tend to perpetuate an unfavourable soil environment. Weed growth, often including legumes, is sometimes excessive and rotation of fields for tobacco may result in an increase both on and in the soil, in organic matter, unsuitable for flue-cured tobacco production. In addition, nitrogen is likely to accumulate in some cultivated tropical soils (to 400 p.p.m. at

the unaccustomed presence of a ram (Underwood and Shier 1942; Hafez 1952; Riches and Watson 1954).

Growth of a follicle, with the production of female sex hormone or oestrogen, rupture of the developed follicle with the shedding of the ovum, and the subsequent formation of the corpus luteum and the production of its hormone, progesterone, are phenomena controlled by three hormones elaborated and secreted by the anterior pituitary gland. A gonadotrophin—follicle stimulating hormone (FSH)—causes growth and maturation of the follicle with the production of oestrogen. The oestrogen so produced is believed to act back on the pituitary, suppressing the output of FSH, and stimulating the output of a second gonadotrophin—luteinising hormone (LH)—which causes rupture of the follicle, shedding of the ovum and formation of a corpus luteum. A third pituitary hormone—luteotrophin—which is identical with the lactogenic hormone or prolactin, acts on the developed corpus luteum and stimulates the secretion of progesterone. During the period for which the ewe is under the influence of progesterone she is in a condition of pseudopregnancy.

These general ovarian-pituitary relationships are discussed by Selye (1949) and are illustrated diagramatically for the ewe, in Figure 1.

The manner by which the seasonal rhythm of light and dark hours controls the basic reproductive rhthym is not clearly understood. Such photoperiodic control of breeding phenomena is widespread throughout the animal kingdom. Marshall (1936, 1942), in reviewing the state of knowledge, concludes that receptors in the head region are involved and that the optic nerve probably is involved in the conduction of the stimulus. There is considerable evidence that a region of the base of the brain, the hypothalamus, contains centres concerned in the control of activity of the pituitary gland (Harris 1948). Subjection of the ewe to a light environment of decreasing hours (Yeates 1949) or to a uniform environment in which the dark-light ratio is 2 to 1 (Hart 1950) causes the onset of breeding activity after a period of 10 to 14 weeks. Presumably, a condition is gradually built up in the light receptor-hypothalamus-anterior pituitary chain, which culminates in the pituitary developing to a point where it can induce an initial ovulation and maintain a series of cycles.

The logical inference is that there is a seasonal fluctuation in the pituitary output of gonadotrophin. Without entering into the perennial controversy about whether or not the hormone content of an endocrine gland is a measure of the hormone output, it would seem logical to expect the gonadotrophin content of the pituitary to be higher during the breeding season than during anoestrus. However, Kammlade, Welch, Nalbandov and Norton (1952) found the gonadotrophin content of the sheep's pituitary to be as high during anoestrus as the highest level during the normal cycle. Unfortunately the complex was not fractionated into its two components, follicle stimulating and luteinising hormones. The authors appreciated the limitations this placed on their conclusions, and suggested that during anoestrus follicle stimulating hormone is secreted but there is a lack of luteinising hormone. Not all the evidence is in favour of this view. The ewe appears able to ovulate all follicles which are developed as a result of the injection of a gonadotrophin, the prime function of which is follicle stimulation (see Robinson 1951 for review). The situation is confused, but it appears probable that photoperiodic control of the onset of the breeding season is effected either by the release of gonadotrophin by the anterior pituitary or by a change in the proportions of the two components of the gonadotrophin complex.

Control of the primary reproductive rhythm may be summarised as follows. Below a certain threshold of daily light hours, a centre in the hypothalamus, responsible for control of the balance of FSH and LH output by the pituitary, is slowly developed. Ovarian activity increases gradually until a follicle is developed to a stage sufficient to start the chain of reactions illustrated in Figure 1. A point is reached at which the production of oestrogen is sufficient to stimulate the release of luteinising hormone by the anterior pituitary, the follicle ruptures, an egg is shed, a corpus luteum develops, and a series of oestrous cycles is initiated.

Similar relationships between the environment, the anterior pituitary, and the gonads exist for the ram, and are illustrated, in outline, with those for the ewe, in Figure 2.

Factors Which Control Oestrus

The first ovulation of the breeding season is not normally accompanied by oestrus (Grant 1934). Furthermore, Cole and Miller (1933) and many others have observed that ovulations induced in anoestrus by gonadotrophin injection are not usually accompanied by heat. The author recently has demonstrated the reason for these so-called "silent heats". Although oestrus may be induced in a fairly high proportion of spayed or anoestrous ewes by the injection of oestrogen, the dose level required is far in excess of the normal physiological level. Furthermore, repeated injections of oestrogen in spayed ewes rapidly induce a refractory condition and the animals will not exhibit normal female behaviour. If, however, oestrogen administration is preceded for several days by the injection of

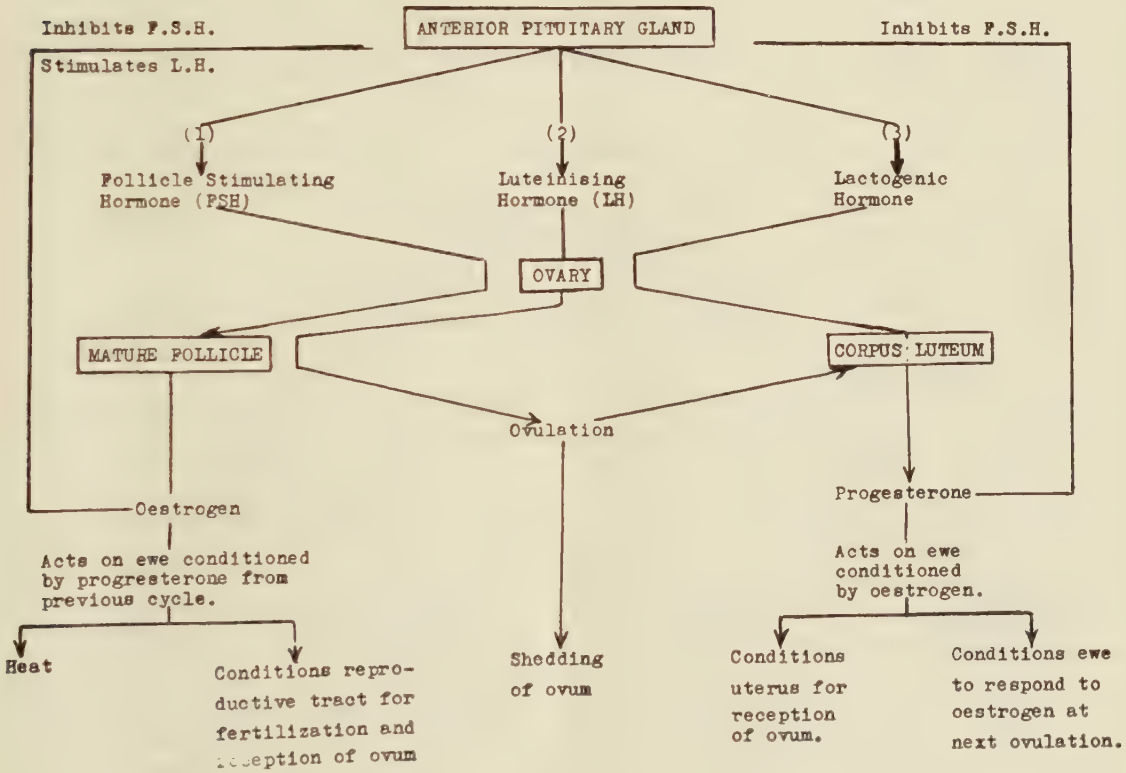

Figure 1.
Ovarian—hypophysical relationships in the oestrous cycle of the ewe.

progesterone, oestrus is induced more readily, a refractory condition does not develop, and the requirement for oestrogen for oestrous behaviour is considerably reduced (Robinson 1954a).

The quantitative requirements, in terms of duration of administration and dose levels, of progesterone and oestrogen have been worked out in considerable detail for the induction of oestrous behaviour and vaginal cornification in the spayed ewe (Robinson 1954b, c; Robinson and Moore 1954). In essence, the efficiency of response to oestrogen increases as the duration of progesterone pre-treatment is increased successively from 3, to 6, to 12 days, commencing respectively 4, 7, and 13 days before the injection of oestrogen. The daily requirement for progesterone is $< 6mg \geqslant 3mg > 1.5mg$. The median effective dose of oestradiol benzoate for oestrous behaviour, when progesterone pre-treatment is continued for 12 days, is about 13 μg and practically all ewes treated will respond to 20 μg (Robinson and Moore 1954).

Studies on the entire ewe (Robinson 1954d) suggest that the developing follicle normally produces oestrogen in amounts equivalent to a single injection of about 20 μg oestradiol benzoate. Such a dose level is insufficient to induce oestrus in a ewe unless she has been conditioned previously by progesterone.

It is concluded, therefore, that oestrus in the ewe is under dual progesterone-oestrogen control. Ewes will accept the ram only at the second and successive ovulations, i.e., after they have been conditioned by progesterone. Failure to exhibit oestrus may be due to either of two causes, namely, to incomplete conditioning due to failure of corpus luteum

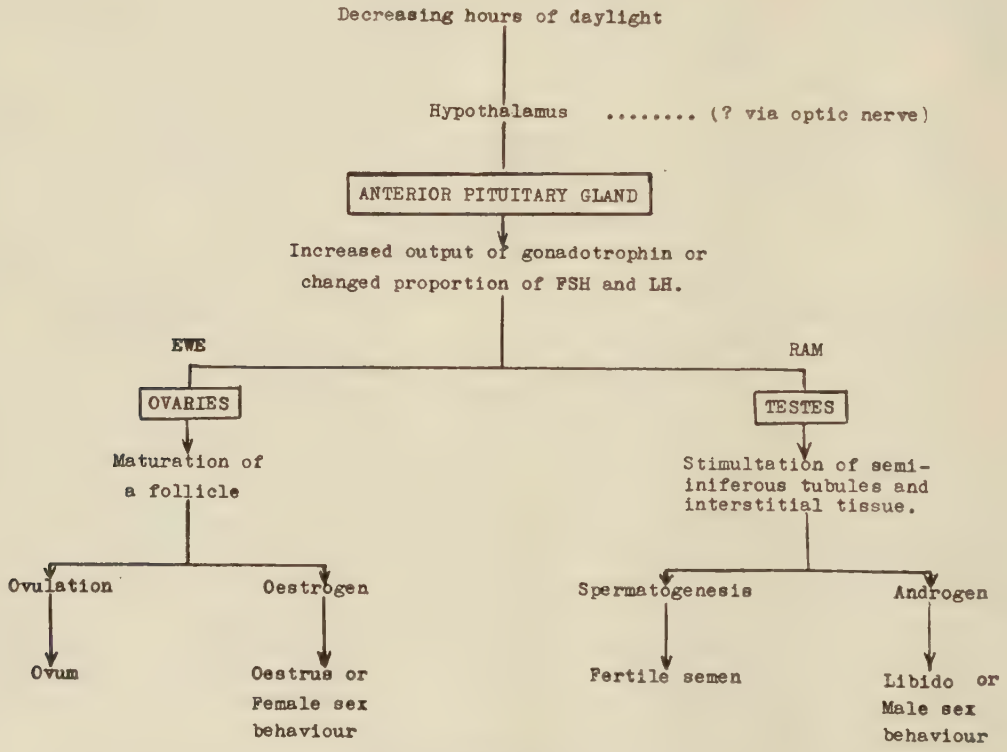

Figure 2.

Relationship between the light environment and reproductive activity in the sheep.

function, or to insufficiency of endogenous oestrogen.

Factors Which Control the Uterine Environment

There is considerable evidence that reproductive efficiency, as measured by the conception rate and young born alive, reaches a peak some time after the onset of the breeding season (Heape 1899; Hammond, Jnr. 1944; Watson 1953). A similar phenomenon is observed in cattle, in which the conception rate to first service after parturition is very low, but increases to a maximum by the third or fourth service or artificial insemination (Olds, Morrison and Seath 1949; Edwards 1950; and others).

Two factors appear to be implicated. Firstly, the mean number of ova shed by the ewe increases towards the middle of the breeding season (Grant 1934; McKenzie and Terrill 1937; Hammond, Jnr. 1944). Secondly, it seems probable, by analogy with the cow, that the proportion of ova which are fertilised and which survive is greater towards the peak of the season, i.e., after the ewe has experienced several oestrous cycles. Direct evidence is lacking on this latter point, but it probably makes a large contribution to the greater breeding efficiency observed in the sheep in mid-season. During anoestrus, the vagina, uterus and fallopian tubes decrease in size and lose their muscular tone (Roux 1936). Under the influence of the ovarian hormones, progesterone and oestrogen, the reproductive tract regains its functional size and condition. It would be rather surprising, however, if it regained a condition suitable for maximum reproductive efficiency without being subjected to at least two or three complete oestrous cycles. In addition to the obvious anatomical and physiological developments which are necessary, there is another factor to be considered. Laing and Day (1947) and Rowson, Lamming and Fry (1953) have demonstrated the bactericidal effect of oestrogen in cattle, and have shown the value of several heat periods for the elimination of a number of infective conditions. To the author's knowledge, the microbial picture in the vagina and uterus of the ewe in anoestrus and at the start of the breeding season has not been studied. Obviously there is a strong probability of the presence of mild infections, at least in the vagina. Furthermore, both vagina and uterus will contain the cellular detritus of months of desquamation of surface epithelium which, even if it proceeds at a very slow rate, would be unlikely to contribute to an optimum environment for sperm survival and transport, nor for survival of a fertilised ovum.

Each successive cycle of increased uterine motility, glandular activity, cervical opening and extrusion of fluid mucus, together with the bactericidal effect of oestrogen, would help to irrigate and cleanse the reproductive tract. It seems a reasonable hypothesis, therefore, that the completion of several oestrous cycles is necessary to bring the reproductive tract to a condition necessary for maximum fertility.

Factors Which Affect Semen Quality

A number of factors have been implicated as affecting the quality of semen. Those of greatest importance are (a) changes in the light-dark ratio, (b) the environmental temperature and (c) the nutritional environment. Usually it is possible to ensure that the rams are in good condition before joining, and so eliminate this last factor. Also, since in this discussion we are primarily concerned with the British breeds of sheep, the deleterious effect of high environmental temperatures is of relatively little importance. Gunn, Sanders and Granger (1942) found that exposure to 4 weeks of maximal daily temperatures of 90°F., and over, markedly depressed spermatogenesis. It is unlikely that such temperatures would be experienced for such

long periods in districts where the British breeds of sheep are kept. While it is a factor which must be borne in mind, its importance appears much less than the diurnal light-dark ratio.

Rams exhibit a seasonal rhythm of reproductive activity, which, while not as noticeable as in the ewes, is highly significant (McKenzie and Berliner 1937; Chang 1941; Gunn, Sanders and Granger 1942; and others). This rhythm has been shown by Yeates (1949) and Moule (1950) to be under photoperiodic control in a manner similar to that of the ewe. The ram attains the peak of reproductive efficiency, both as regard quality of semen and sex drive, in the autumn and winter months, that is when the days are short. During the spring and summer months libido is reduced but in the author's experience is never so low that the rams will not serve ewes which are in full oestrus. Semen quality is also impaired and may constitute a limiting factor in fertility.

The relative fertility of the ram at different seasons of the year is most difficult to assess, due to coincident fluctuations in female fertility. One is dealing with an interaction between the male and female organisms. Consequently, the best that can be done at present is to collect semen samples and attempt to assess their fertilising capacity by their physical and chemical characteristics. This is no solution to the problem.

Less is known about the intermediate control of spermatogenesis, accessory fluid production and libido in the ram than about the corresponding phenomena in the ewe. Presumably the photoperiodic effect is mediated in a similar manner, as outlined in Figure 2.

By analogy with observations made on other species—always dangerous ground—there is almost certainly an interaction between the testicular sex hormones and the pituitary gonadotrophins. Thus it is well established that androgens suppress the pituitary output of FSH in the male, just as oestrogens do in the female (Ludwig 1950). Furthermore, the pituitary gonadotrophin responsible for sperm production, namely FSH, differs from that responsible for the production of androgen, namely LH. Hence the fact that a ram is working well by no means infers that he is fertile. In fact, excessive male sex hormone may tend to *reduce* sperm production.

Artificial Stimulation of Breeding in the Ewe

This problem can be approached at three physiological levels.

1. The anterior pituitary can be stimulated to the production and/or release of gonadotrophin by manipulation of the diurnal light-dark ratio.

2. Gonad stimulating substances may be injected to stimulate the ovaries to the production of ova and ovarian hormones.

3. The higher centres concerned with reproductive behaviour may be stimulated by the injection of ovarian hormones.

1. *Manipulation of the diurnal light-dark ratio*

This is the most fundamental approach and as a consequence is the most successful. Regular oestrous cycles and a high degree of fertility can be attained by housing the sheep for several months and artificially controlling their light-dark environment. However, the high costs and practical problems associated with this technique preclude its practical application.

2. *Stimulation of the ovaries by the injection of gonadotrophins*

Some limited successes have been attained using the gonadotrophins alone and in combination with other hormones. Of the various preparations available, "Pregnant Mare Serum" (PMS) is the

most useful, on the grounds of availability, cost, and reliability of action. Ovulation can be induced with great regularity by the subcutaneous injection of 1,000 i.u. of any one of a number of commercial preparations, which are marketed under various trade names. Such an ovulation usually is unaccompanied by oestrus, as the animal has not previously been conditioned, by progesterone, to respond to the minute quantity of oestrogen produced by the ovary (Robinson 1954 a, b, c, d).

If a second injection of PMS is given 16 or 17 days after the first, a further ovulation is induced, and this time is often accompanied by oestrus (Cole and Miller 1933). The progesterone produced by the corpus luteum, which forms at the site of the first induced ovulation, conditions the ewe to respond to the endogenous oestrogen produced by the follicle which develops as a result of the second injection of gonadotrophin. Service to this second ovulation is frequently fertile, but generally speaking is not very reliable. Cole, Hart and Miller (1945) reviewed work conducted over a period of 11 years in California, and reported that 7 per cent. of ewes came into oestrus after one injection of PMS but none conceived. Following two injections the corresponding figures were 34 per cent. served of which only one-third conceived.

If progesterone is injected for several days prior to PMS, oestrus accompanies the first ovulation which is induced (Robinson 1952, 1954 e; Dutt 1952, 1953; Dauzier, Ortavant, Thibault and Wintenberger, 1953). The reliability of the oestrous response when PMS is given 4 days after the commencement of progesterone injection is considerably enhanced by greater subdivision of the dose of progesterone (Robinson 1954 e). A further increase in reliability is achieved by prolonging the period of stimulation by a further 3 days. A total of 75 mg progesterone, administered over a period of 6 days in 12 twice daily injections in oil, followed 40 hours after the final injection by 1,000 i.u. PMS, will result in oestrus with ovulation, within 48 hours of gonadotrophin injection, in practically all the ewes treated (Robinson 1954 d).

Despite the apparently normal nature of this oestrus-ovulation response, lambing results have been poor. In one trial conducted in the early summer of 1952 with Suffolk and Suffolk crossbred ewes at the Werribee Research Station and with Romney Marsh ewes at Mr. Ivor Manton's Romney Marsh stud, "Nardoo", Monegeeta, of a total of 46 ewes which received progesterone-PMS treatment, 43 were served of which only 17 (37%) lambed as a result of that service (Robinson 1954 f). The following year a large-scale trial with Romneys, treated in a variety of ways with progesterone and PMS and artificially inseminated, yielded most disappointing results despite the use of semen which appeared to be of good quality (Robinson 1954 d).

It is obvious that many problems remain. The first two requirements for fertile mating, namely, ovulation and oestrus, are satisfied. Furthermore, the author has observed no lack of sex drive in the rams. This leaves as suspect, the environment of the maternal reproductive tract, the viability of the ova, and the quality of the semen. Judged by appearance, the latter would not have constituted a limiting factor in the fertility of the ewes used in the artificial insemination experiment mentioned above. Nevertheless, the appearance of ram semen, and particularly its motility, is not necessarily an index to its fertilising capacity, as witness the experience of Emmens and Blackshsaw (1954) with ram semen thawed out after deep freezing. Consequently the possibility remains that the quality of the semen produced during

the spring and summer months contributes to the subfertility observed when ovulation and oestrus are induced artificially in the ewe.

The general question of the maternal environment and the relation of a succession of oestrous cycles to fertility has been discussed above. The quantitative dose-time relationships of the ovarian hormones, progesterone and oestrogen, for the induction of regular oestrous cycles have been worked out recently (Robinson 1954 a, b, c; Robinson and Moore 1954). With this information at hand it will be possible to induce several anovulatory cycles before the induction of ovulation and so test the hypothesis that the uterine environment, as determined by the balance of ovarian hormones and the duration of their stimulation, is a factor contributing to the subfertility following artificially induced breeding.

Murphree, Warwick, Casida and McShan (1944) are of the opinion that ova shed under the influence of PMS are potentially incapable of normal development. The author does not conform to this view. Growth and atresia of follicles with development and resorption of ova is a continuous process throughout anoestrus (Hammond, Jnr. 1944; Robinson 1950). A number of follicles at various stages of development are present at any one time, and only those which are furthest advanced and capable of responding to administered gonadotrophin will develop to a stage where they will ovulate. It seems unreasonable to expect that ova shed under such circumstances will be abnormal but, nevertheless, the possibility remains.

One point needs emphasising. No method of ovarian stimulation, using a single injection of gonadotrophin, will induce a series of ovulations. There is but one chance of conception. Successive ovulations, with oestrus, may be induced by a series of gonadotrophin injections spaced at 16-day intervals, but as there is no indication of which ewes have held to service, all ewes have to be treated. Gonadotrophic hormones, being protein in nature, have to be prepared from biological sources, and are expensive. Consequently, as a practical measure, emphasis must be placed on obtaining a fertile service to a single ovulation accompanied by oestrus.

A serious problem of practical management also exists. Progesterone-PMS treatment results in a remarkably uniform response, in terms of time of ovulation and onset of oestrus. Eighty per cent. of treated ewes may be served within a period of 6 hours, commencing about 24 hours after the injection of PMS. This places an enormous strain on the capacity of the rams. They work vigorously and it seems likely that, even if one joins with an abnormally high proportion of rams—say 10 per cent.—ewes which are served relatively late will be inseminated with sub-standard semen. This is a very serious practical problem and effectively limits the number of ewes which can be brought into oestrus each day. It has been reported (Polovceva 1938) that an average of 30 ejaculations will exhaust the supply of spermatozoa in the epididymis of the ram. On the basis of the 8 or 9 days reported by Phillips and McKenzie (1934) as required for the transit of spermatozoa through the epididymis, the exhaustion caused by one day of intense activity would be expected to limit the fertility of the ram for this period. The logical, and probably the ultimate, answer lies in the use of artificial insemination. However, results of the only trial to date have been disappointing.

3. *Induction of oestrus by the injection of ovarian hormones*

As the primary function of female sex hormones, or oestrogens, is to induce the physical and psychic changes necessary for the ewe to accept the ram, there is

little logic in their use for artificial breeding. Heat is induced, but there is no egg present to be fertilised. This is true of the many oestrogens, both natural and synthetic, which have been used, ranging from oestrone to oestradiol cyclo-pentyl-propionate (E.C.P.). Furthermore, the dose levels which invariably have been advocated are far in excess of normal physiological levels of oestrogen production. While oestrus may be induced in spayed ewes with oestrogen alone, relatively large dose levels are required and the response is unreliable and may be abnormal. For a normal response to physiological dose-levels, preconditioning with progesterone is necessary.

Notwithstanding these remarks, there are isolated reports that the injection of oestrogen has been followed by ovulation. Thus Hammond, Jnr., Hammond and Parkes (1942) observed ovulation, with oestrus, in 9 of 15 ewes treated with large doses of oestrogen. There is also evidence that, under some circumstances, a single injection of oestrogen will initiate a series of oestrous cycles in some of the treated ewes (Anderson 1938; Opperman 1943; Thibault, Ortavant, Desbois and Lowran 1948) but the response is so unreliable, and the lambing results so poor, that the expense of treatment is unwarranted.

A particularly interesting observation has been made, independently, by Dutt (1952, 1953), Dauzier and Wintenberger (1952), and the author (Robinson 1954 d, e). Progesterone administration, over a number of days, was followed several days after cessation of treatment, by ovulation in 5 of 6 ewes treated by the author in each of 2 experiments, and in 5 of 9 treated by Dutt. The mechanism of this phenomenon is obscure. Nevertheless these independent observations do suggest the possibility that gonadotrophin injection ultimately may be unnecessary, at least in some circumstances.

This last observation does not invalidate the earlier statement regarding the use of oestrogen. It is applicable only to the possible use of progesterone without an injection of gonadotrophin. All the available evidence suggests that the injection of oestrogen in any form will not induce fertile mating in any but a small and unpredictable proportion of anoestrous ewes.

Artificial Stimulation of Breeding in the Ram

As for the ewe, there are three alternative procedures, each operating at a different physiological level.

1. *Manipulation of the diurnal light-dark ratio*

The general problems associated with the practical application of this technique are similar to those applicable to the ewe. However, since fewer animals are involved, the housing and control of the photic environment of several valuable rams may be justified in some circumstances. This would be the case only if one were certain of having the ewes in a state of maximum fertility at the right time.

2. *Stimulation of the testes by the injection of gonadotrophin or thyroxine*

The possible value of the various gonadotrophic preparations for the stimulation of sex drive and the improvement of semen quality has not been studied to any extent. It would appear to be a logical approach. There is considerable evidence that the overall metabolic rate is involved in seasonal fluctuations in fertility of the ram (see Maqsood, 1952, for review). Thyroxine therapy appears to increase both sex drive and semen quality during the summer months, provided it is administered in physiological amounts and treatment is initiated when the rams are at the peak of their reproductive activity. The assessment of the practical value of such treatment is rendered very difficult because of the problems of ade-

quate controls and of relative female fertility.

3. *Induction of sex drive by the injection of testicular hormones*

The use of androgens for the stimulation of the ram is sometimes advocated. There is no rationale for this recommendation, and much the same arguments apply as against the use of oestrogens in the female. Direct evidence for the ram is lacking, but in other species injection of androgen usually causes a reduction in spermatogenesis. Its sole effect is to increase libido, or sex drive. It will not improve the quality of the semen.

An advertising pamphlet widely circulated in Australia within the past two years advocated the use of 50 mg testosterone propionate for the stimulation of sex drive in rams. This dose level is of the order of that used by the author some years ago to stimulate libido in several Suffolk rams during the summer months (unpublished data). The response was striking and the rams showed an excess of zeal. However, semen collected 48 hours after the injection of testosterone—some 24 hours after the rams commenced working — contained practically no live sperm. Recovery was gradual and did not appear to be complete till over a week had elapsed. In the meantime the rams had continued to work well, but almost certainly were sterile.

It is probable that this was due mainly to exhaustion of the rams' reserves of semen rather than to suppression of spermatogenesis. The normal balance of endocrines was upset and libido was excessive, with consequent rapid exhaustion of the reserves of spermatozoa stored in the epididymis. This is a point which requires study.

Consequently the use of androgenic hormones in rams cannot be recommended at the present time. It is true that at certain dose levels and in certain circumstances they may have a use. As yet we have no idea of the physiological levels of production in the body, and until we have such information their use will be on an empirical basis and liable to do more harm than good.

Conclusions

At the time of writing, the problem of the practical control of the time of lambing remains unsolved. Nevertheless, it may soon be possible to ensure this control, at least as far as the ewe is concerned.

It appears that the potential fertility of the ewe, as of the cow, increases with a succession of several oestrous cycles. It seems reasonable to suppose, for the reasons discussed above, that this is due to an improvement in the maternal environment, although the potential capacity of the ovum to develop cannot be entirely disregarded.

If the ewes are put through one or two anovulatory oestrous cycles, using progesterone and oestrogen, prior to the induction of ovulation with oestrus by an injection of gonadotrophin, it seems reasonable to believe that the maternal environment will be brought to an optimum state for maximum fertility at the time of this ovulation. There still remain the problems associated with the relative fertility of the rams, and their management, to ensure that each ewe is inseminated with a fertile ejaculate.

It can be stated, with certainty, that the practical solution of this important problem will not come from the empirical use of any single hormone. The phenomena concerned with full reproductive efficiency involve the action and interaction of a number of hormones, the balance of which is exceedingly critical. The ultimate solution will come from the application of our knowledge of the quantitative relationships of the various hormones and their interactions, one with the other. This knowledge is accumulat-

ing rapidly. By the use of a combination of hormones, administered in physiological amounts, and at physiological time intervals, it seems probable that the female aspects of this involved problem may be solved in the near future. There then remain to be solved the problems in respect to the male aspects of fertility, management, and application in the field.

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THE USE OF AIRCRAFT IN AGRICULTURE

By HELEN M. WRIGLEY

The first recorded instance of aircraft being used to assist farmers was back in 1919 when a farmer in U.S.A. chartered a small plane to fly low over his pest-infested crop while he lay on the wing and shook insecticide from a bag.

From this hair-raising beginning, aerial agriculture had become an established industry. The greatest development has taken place since the end of the second world war and it is estimated that in the last few years millions of acres in the world's agricultural countries have been treated from the air with seed, fertiliser, insecticide or weedicide. The results have been important to a world which is constantly endeavouring to feed itself adequately.

Experience Overseas

By far the greatest advance has been made in America where it is estimated by the U.S.D.A. that 6,000 planes are engaged in agriculture, mainly in the southern and south-western States from Florida to California.

Aircraft are regarded as being indispensible for controlling grasshoppers and forest pests and are most satisfactory for controlling pests in peas, beans, tomatoes, cotton and wheat. Selective hormone weedicides are also applied extensively from the air in America and Canada for controlling weeds in cereal crops, particularly rice. It is claimed that this practice has increased rice yields in California by up to 40 per cent. Aerial distribution of fertiliser and seed is also practised widely, and in California, almost the entire rice crop is sown by this method.

Other uses of aircraft in American agriculture are spraying orchards with hormone preparations to prevent preharvest drop of fruit, and spraying mature cotton crops with DNBP and endothal to defoliate plants thereby assisting mechanical harvesting.

Aerial agriculture has been used successfully, if less widely, in other countries. In Russia, Germany and France forest pests have been controlled on a huge scale. In Africa, the Middle East, and particularly Pakistan, grasshoppers have been successfully controlled in this way using the comparatively new insecticide aldrin, at the rate of 2 oz per acre, diluant being diesel oil. In much of East Africa, the tsetse fly which has been the limiting factor in cattle breeding because it carries the disease nagana, has been completely wiped out with DDT and BHC sprayed from the air. The main fly breeding grounds were confined to 200 square miles in a game reserve which were inaccessible to anything other than aircraft. In the Sudan, by spraying from the air with DDT, more than 17,000 acres of cotton were saved in one season from what seemed likely to be complete destruction by the cotton jassid.

Hill country in the United Kingdom and New Zealand has been improved by top dressing from the air. In New Zealand work began in 1949 and by 1952 one hundred aircraft owned by 24 firms were engaged in top-dressing with superphosphate and trace elements. In 1952, 89,000 tons of super-

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phosphate were spread over 830,000 acres and an additional 30,000 acres were seeded to pasture. An increasing area is also being sprayed with hormone weedicides. The planes operate from small landing strips prepared by the farmers near the country to be treated. The average length of strips is 5-600 yards which allows Tiger Moths to work an average of a 3-4 mile radius. The strips cost from a few pounds when built on flat country to several hundred when on hill tops. Accessibility to strips is very important and in many cases expensive bulldozed tracks have to be made so that trucks can reach the strips with fertiliser supplies.

Experience in Australia

Australia is far behind most other major agricultural countries in the adoption of aerial farming. Although commercial aerial agriculture commenced here just after the war, little progress has been made in developing machines, equipment or techniques. Until the last few months the only planes available have been makeshift converted trainers, this is because there have been insufficient big aerial contracts to tempt contractors to spend large sums in purchasing superior aircraft overseas. This position is beginning to change as confidence is built up following the increasing use of aerial farming.

Distribution of Fertiliser and Seed

During 1953, distribution of superphosphate alone or in combination with pasture seed, mainly subterranean clover, has greatly increased in New South Wales, where most work has been done. Most of the country treated is hill country which is inaccessible to ground machinery.

As an emergency measure after flooding, aerial sowing has been of real value and, for example, after the last flood in the Lachlan Valley, fine pastures of lucerne, clover and Wimmera ryegrass were established on land which could not be worked with ground machinery. The same principles apply to establishing improved pastures on rice stubble. Experimental seedings carried out at Wakool proved successful provided the water was properly drained off before sowing and the stubble was not too heavy. Aerial farming may also have an important role in developing the Northern Territory and the Kimberleys by assisting in the establishment of rice fields in suitable areas.

Pest Control

In pest control work, aircraft have the great advantage of being able to treat extensive outbreaks quickly without disturbing the crops. They also have the advantage of being usable when ground is too wet to operate ground machinery. The first major attempt at insect control from the air took place in 1946 when a grasshopper plague in Victoria was controlled by the RAAF. Using 4 Beauforts which are by no means ideal for the work, 30,000 acres were sprayed with 120,000 gallons of BHC from a height of 25 feet. BHC baits were also laid from the air. Since then aldrin has been used successfully in experiments on the Murrumbidgee Irrigation Area and at Gunnedah in New South Wales, but for ordinary routine control it is considered by the government entomologists that BHC is superior.

Crop spraying with insecticides has been practised fairly widely in all Australian states. Most spectacular results were achieved with control of *Heliothis* caterpillar in linseed and flax crops in north-west New South Wales, Queensland's Darling Downs, western Victoria and South Australia. The pest was proving a limiting factor in production prior to 1947, but since the adoption of aerial spraying with DDT using 1 lb per acre, the linseed industry has become firmly established. The success of this practical treatment was followed by experiments with other crops, and the method has been successfully used on a

field scale in all states against *Heliothis* on peas and lucerne, potato moth on potatoes and army cutworm in malting barley and wheat.

Weed Control

Aerial spraying with selective weedicides has also been used for controlling a variety of weed pests including variegated and saffron thistles, blackberry, Bathurst and Noogoora burrs, wattle and ti-tree scrub. Control of water hyacinth, a serious pest in coastal water courses presents a special problem which may be solved by aerial spraying with hormone weedicides.

In Western Australia large areas of the wheat belt have been sprayed for skeleton weed using 2,4-D. A 75 to 80 per cent. kill is achieved which farmers regard as practical control. The Department of Agriculture in Queensland is enthusiastic about the great potential value of applying hormone weedicides from the air in controlling brigalow scrub and already contracts for some hundreds of thousands of acres have been let.

When spraying weeds in cereal crops, agriculturists recommend that the crop should be 5 to 6 inches high and well rooted prior to spraying to avoid damage. The selective weedicides present a problem at any time due to wind drift carrying fine spray to near-by crops and damaging them. Spraying from the air certainly intensifies the risk and special care must be taken to spray under ideal climatic conditions or consequences may be serious.

Vermin Control

Poison baits for dingo and wild dog control have been distributed aerially in Western Australia, South Australia and Queensland. To distribute the baits evenly along rivers and tracks to water holes, it is essential to have a machine which can come in low at relative slow speed and one which has a maximum of manoeuvrability. It is difficult to assess the kill and though the job is not done as efficiently as from the ground, it provides the only practical method in remote localities which contain many of the main breeding areas. Aerial distribution also has the advantage of being much cheaper.

Soil Erosion and Fertility

The question arises as to whether aircraft may not be able to play a part in solving two of Australia's great national problems—soil erosion and the raising of soil fertility by the application of trace elements to huge areas of land which, in many instances, could be turned into farming or pastoral country of high potential. In many places in Australia hill country has been topdressed with very good results by graziers who claim that the method is economical under those conditions.

Dr. J. Griffiths Davies, estimates that there are nearly 343 million acres of reasonably well watered country in Australia which are deficient in plant nutrients and which could be transformed into fertile pasture by applying the necessary minerals. For some years now agriculturists have been determining the extent of mineral deficiencies by chemical and biological tests, and mapping the areas concerned. Much of this country should be classed as inaccessible and it is conceivable that aircraft could be the most effective and quickest method of applying fertilisers to these extensive areas, as well as the most economical. In New Zealand both copper and cobalt have been applied to hill country from the air. This approach to aerial agriculture is probably of the greatest significance in Australia.

Types of Aircraft

Requirements for a satisfactory agricultural aircraft are low overhead and running costs, manoeuvrability, ability to withstand harsh climatic conditions and, of course, availability. The undercarriage must be strong enough to absorb the vertical accelerations of a deck

landing aircraft and sufficiently resilient to protect the airframe from pounding inflicted by continuous operation from rough land. Short take-off run and low landing speed are necessary; it it vital that stalling speed is low and that there is good controllability at the stall. The plane must be able to achieve a good rate of climb and pilot comfort and good field of vision are also important. Reloading must be easy to save time; one minute turn rounds are not impossible. In an emergency it must be possible to jettison loads of fluid or dust quickly. For efficient operation the aircraft must be readily convertible from fluid to dust application.

Throughout the world the light fixed wing aircraft is preferred by the agricultural aerial contractors. The payload of this class is up to 1,500 lb and they are able to land and take-off close to the area being treated. The use of large aircraft with payloads of 5,000 lb or more has been restricted to specialised work. The big payload has obvious advantages when large-scale work is being done, such as the spraying of large forest areas to control insect pests. Pin-point distribution is not required and it is preferable for planes to make long sorties rather than many smaller ones from a number of small strips. However, in general, economics do not favour the use of large aircraft in agricultural aviation.

The medium class aircraft typified by the de Havilland Beaver have payloads of between 1,500 and 5,000 lb. Many experts think that this is the best available aircraft for agricultural purposes, providing reasonable utilisation can be expected, because it carries double the load of the light aircraft, yet is still manoeuvrable.

In America there is a wide range of light aircraft available. Most of them are special versions of aircraft designed initially for other purposes. About half the aircraft used are, on a U.S.D.A. estimate, biplanes of the Stearman type with a payload of 515 lb. These planes, formerly used as military trainers, are now wearing out rather rapidly and are costly, being replaced by slightly smaller cub-type planes, particularly the Piper Cub (payload 490 lb) and the Cessna (payload 798 lb). There is an increasing demand for an aircraft specifically designed for aerial agriculture and several countries are working on the project.

One of the most significant developments so far is the machine designed by the Agricultural and Mechanical College of Texas, working with the U.S.D.A. and the National Flying Farmers' Association. Named the Ag-1, it was specially designed for spraying, dusting, fertilising and seeding. It is a low wing all-metal construction, powered by a 200 h.p. engine. The cockpit is open, but framed. There is a 27 cu. ft. hopper in the fuselage forward of the cockpit and in-wing rubber lined tanks of 125 imp. gall. capacity. Operational payload is between 800 and 1,200 lb, depending on the limitations on take-off weight imposed by the operating surface.

Compared with the wide range of aircraft available in America, the choice in Australia is limited. Tiger Moths DH-82, with operational payload of 450 lb are used almost exclusively, but experience has shown that the payload is too small. The Auster J-5 (payload 650 lb) and Chrisler CH-3 (payload 770 lb) have a more suitable capacity, but neither can be satisfactorily converted. Quite recently a number of Cessnas has arrived in Australia.

Most planes used in agricultural aviation in New Zealand are Tiger Moths, but the small payload is a disadvantage and recently 8 DHC-2 Beavers with a payload of 1,850 lb have been used very satisfactorily. The normal load on spray work is sufficient to treat 400 acres.

The Beaver is very popular with aerial agriculture contractors in Canada. It was designed in Canada to meet the needs

TABLE I.

Characteristics of aircraft at present being used widely in agriculture.

Type of Aircraft	Speed m.p.h.		Rate of Climb	Take-off	Payload
	Cruise	Stall*	f.p.m.	yards	lb
Auster J5	100	30	650	160	650
de Havilland Beaver	140	47	1,020	185	1,850
Cessna	150	55	1,050	125	798
Piper Super Cub	95	45	680	—	490
AG-1	100	45	600	430 (to 50 ft.)	1,214

*It must be presumed that stall speeds are taken at maximum all-up weight.

of farmers and backwoodsmen, and as such it is used to fetch and carry generally as well as being regarded as just another piece of farm equipment. It is powered with a 450 h.p. Pratt and Whitney Wasp Junior engine, has a speed range of 60 to 120 m.p.h. and a stalling speed of 47 m.p.h. Fully loaded, it takes off in 504 feet, no wind. The agricultural version is the result of detailed investigations into all the requirements of an agricultural aeroplane. The makers regard it as a specialised machine for farm or forestry work and it can be rapidly changed from superphosphate spreading to spraying or supply dropping. To utilise an aircraft as a piece of farm equipment, and utilise it efficiently, it is necessary to be able to change it rapidly from one purpose to another.

The Beaver was designed to withstand rough treatment and, as it is essentially a piece of farm equipment, maintenance is simple.

Equipment

The special equipment used in aerial agriculture is essentially simple. The metal hopper is used for carrying solids, e.g., fertiliser or insecticidal dusts; a rubberised plastic bag tank is placed inside the hopper for liquids. It is practically impossible to wash hormone solution from the sides of the container and to prevent subsequent damage by traces of hormone weedicide, an individual tank bag is kept for each solution.

In Australia a specially designed hopper is used for aerial sowing. It has dual sided walls, the inner ones having a series of louvre vents through which air picked, from air scoops on the outside of the fuselage, exerts pressure on the seed, ensuring an even flow. Within practical limits the bigger the hopper the better, provided it does not mean increasing the complexity of the aircraft. A large capacity hopper means fewer trips to refill, and these flights are non-revenue earning ones. Solids pass from the hopper through a chute and directly into the air, where dispersion takes place in the slipstream. Design of the chute must ensure that the material is kept moving at a controlled rate.

Fluids are discharged from the bag tank through nozzles on a spray boom or through a new American invention called a rotary brush, which eliminates the awkward boom. The fluid flows by gravity from the tank through a short pipe which just clears the fuselage. On the ends of the pipe are nozzles surrounded by

spinning circular brushes. Centrifugal force flings the liquid out to the periphery of the rotating units, where the passing air shears the liquid into drops. Output can be changed by regulating the rate of flow of the liquid from the tank. Speed of rotation, number and spacing of disks and brushes, and, in the latter, the size of individual bristles, govern atomisation. It is essential that the design of the spray apparatus ensures constant flow and enables the rate of application and size of droplets to be controlled. It is specially important when hormone weedicides are being applied that there is a shut-off valve at the nozzle which enables complete and instantaneous stoppage of the flow.

Flying Technique

Aerial agriculture involves something new in pilot technique. It requires extreme care, ability to fly really accurately, and complete confidence in the aircraft. After take-off, the machine must be climbed at its maximum efficiency until it reaches operation level and then flown at a pre-determined height above the terrain. The load must be released to give maximum spread. At the same time allowances must be made for wind alteration. Since many strips can be used in one direction only, the pilot must be able to land and take-off up, down or cross wind with reliability and complete accuracy.

Problems

The main problems which are beyond the control of the operator are air movement, both wind and convection, and indirectly, temperature and humidity. Any of these factors can change greatly within seconds and over a few hundred feet.

Wind is the worst problem as it may prevent regular coverage of the treated plants and may cause spray or dust to drift beyond the treated area. This is very important when hormone weedicides are being used as drift may cause irreparable damage to neighbouring crops. Maximum permissible wind velocity for treating crops should not exceed 10 to 15 m.p.h. In an effort to minimise the effect of wind, American workers have done a vast amount of research into droplet size and altitude of flight. They have ascertained that in a wind of 1 m.p.h., a 200 micron drop released 10 feet above the ground will drift about 6 feet. If the some sized drop is released in a 10 m.p.h. wind from an altitude of 50 feet, it will drift about 300 feet. Under the latter conditions a 20 micron drop will be carried 3½ miles. These facts are important in getting maximum results from aerial application as well as guarding against contamination of neighbouring crops with hormone weedicides.

In New Zealand it has been determined that a breeze of 10 m.p.h. is sufficient to stop Tiger Moths from distributing superphosphate. If granulated or screened superphosphate were being used, Beavers, being larger aircraft, can cope with breezes up to 25 m.p.h.

Convection currents influence the effectiveness of aerial spraying and dusting as much as wind does. Convection is an upward flow of air which occurs when the ground temperature is higher than the air temperature. Currents usually become noticeable as the sun warms the ground and considerable force may have been developed by afternoon. There is no simple way to determine the amount of convection in an area, but a fairly workable rule is that operations should cease when the pilot finds the air bumpy or when the lighter parts of the spray or dust cloud show a tendency to rise.

Temperature and humidity affect spray distribution indirectly. It has already been stated that increasing temperature promotes convection. It also increases evaporation rate, which may be very important when finely atomized, highly volatile materials are being applied. Humidity is important for its effect on the evaporation of water spray. The U.S.D.A. records an instance of a finely

atomised water spray applied on a hot dry morning, evaporating before it reached the ground.

The best time to spray is from daylight to 9 or 10 a.m., when air movement and temperature are at their lowest and humidity at its highest. In all cases local conditions must be considered before the final decision is made.

Economics

Cost is the crucial consideration in the future of aerial agriculture. However, as a generalisation, it is justifiable to state that country inaccessible to ground machines warrants the use of aircraft for improving it by fertilising or seeding, or controlling pests or weeds. Experience has also shown that in emergencies, like pest plagues, the use of aircraft is recommended irrespective of terrain. In the present days of high labour costs, any method which reduces the time taken to complete any operation must be considered. This will tend to weigh the balance in favour of aerial application of fertilisers and pesticides.

To make aerial agriculture pay, an all-the-year-round programme is necessary for the planes; they must be used for all purposes, not just one or two operations. Moreover, equipment and techniques need to be improved to a higher pitch of efficiency than is possible with the light converted aircraft. At present many of these only average 5-600 hours per year, which is not an economic proposition.

Despite the arguments one way or the other, it cannot be denied that aircraft in agriculture have gone well beyond the experimental stage, and it now rests with agriculturists and aviation engineers to see that Australia gains maximum benefit from this revolutionary piece of farm equipment.

(*Received for publication, September* 5, 1954).

BOOK REVIEWS—

THE APPLICATION OF RESULTS OF RESEARCH

COMPILED AND EDITED BY VERA CONNELL IN COLLABORATION WITH THE BRITISH COMMONWEALTH SCIENTIFIC OFFICE

(*Butterworth's Scientific Publications, London,* 1954, *pp. vii* + 212; *Price* 21/-. *English*).

This book is concerned with extension work, both agricultural and industrial. The theme is that what is most urgently needed is not to increase our knowledge but to apply what is already known. Before this can be done, the first need is to diffuse each piece of knowledge as widely as possible.

The book is an up-to-date version of a report prepared by Mrs. Connell for the British Commonwealth Scientific Official Conference in 1952, embodying the principles and methods in use in the several British countries; a short reference is also made to American methods, particularly to the extension work of Tennessee Valley Authority. In the first 41 pages the principal problems are set out; thereafter each country is discussed separately, Australia being given 25 pages, including the agricultural extension services of the states (8 pages) and the agricultural research liaison section of C.S.I.R.O. (one page).

While the book is not mainly concerned with agriculture, it is a valuable source of reference, and many of the principles and problems discussed are common to both industrial and agricultural work.

G. W. LEEPER.

ORGANIC CHEMICAL HERBICIDES

By S. W. PRESTON

In reviewing the role of organic chemical herbicides in Australian agriculture it is appropriate to first quote from an address by Liebig to the meeting of the British Association for the Advancement of Science held at Liverpool in 1837.

> "Organic chemistry has made its first step, and already its field has been extended to a very surprising degree. We meet every day with new and unexpected discoveries. It is, however, remarkable that in the country in which I now am, whose hospitality I shall never cease to remember, organic chemistry is only commencing to take root. We live in a time when the slightest exertion leads to valuable results, and if we consider the immense influence which organic chemistry exercises over medicine, manufacture and over common life, we must be sensible that there is at present no problem more important to mankind than the prosecution of the objects which organic chemistry contemplates. I trust that Englishmen of Science will participate in the general movement, and unite their efforts to those of the chemists of the Continent, to further the advance of a science which, when taken in connection with the researches in physiology, both animal and vegetable, which have been so successfully prosecuted in this country, may be expected to afford us the most important and novel conclusions respecting the functions of organization."

It was as a direct result of Liebig's challenge that the Royal College of Science was established under the direction of Hofmann, and it is of interest to note that the first research report included a description of the fractional distillation of coal tar and the isolation for the first time of benzene—a compound which has unquestionably contributed more than any other to the development of organic chemicals for use in agriculture in general, and of organic chemical herbicides in particular.

It is noteworthy, also, that the "prosecution of the study of organic chemistry taken in connection with the researches in physiology" as suggested by Liebig, has been directly responsible for the discovery of natural and synthetic growth regulators and with them the introduction of the hormone herbicides which, in the field of weed control chemicals, have constituted an advance which may justly be compared with the advance made in the insecticide field following the introduction of D.D.T.

Classification of Herbicides

Developments in organic chemical herbicides at the present time are so rapid and the field itself so extensive that it is impossible to cover the subject with any degree of completeness. It is proposed, therefore, to attempt to classify them in relation to their general characteristics as herbicides and to illustrate differences between and within the classes by individual examples.

S. W. PRESTON is Chief Research Officer in charge of the Applications Research Department of Timbrol Ltd. in Sydney. *This paper was read at the 30th Meeting of A.N.Z.A.A.S., held at Canberra, January 13th to 20th, 1954.*

The study of the mechanism of selectivity is thus of the greatest importance in the approach to weed control problems.

The mode of action of dinitro phenols has been shown to be associated with protein coagulation and the inhibition of the coupling during the oxidation phases of the phosphorylation cycle. At low concentrations, a stimulation of respiration occurs, but at the concentrations normally employed for selective weed control complete inhibition of respiration of susceptible weeds occurs which is followed by their death.

Commercial use of the dinitro phenols is of great importance for the control of weeds in canning peas, onions, flax and lucerne. As a pre-emergence spray, they have been used for killing germinating weeds and grasses in cotton, corn and many large seeded vegetable crops. As emulsified oil solutions, they have been used for general weed control along fences and ditch banks where mowing is impractical. The chief Australian usage is on canning peas and flax.

Translocated Herbicides

Chief translocated herbicides of commercial importance are the synthetic plant growth regulator or hormone herbicides such as phenoxyacetic acid derivatives of which 4-chlorphenoxyacetic acid, 2,4-dichlorphenoxyacetic acid, 2-methyl-4-chlorophenoxyacetic acid and 2,4,5-trichlorphenoxyacetic acid are typical examples. Other compounds which have shown promise as translocated herbicides are the substituted benzoic acids.

2,4-dichlorphenoxyacetic acid enjoys the widest range of any organic chemical herbicide. World production amounts to many thousands of tons and is applied annually to tens of millions of acres of which more than two million are in Australia.

The herbicidal activity and selectivity of 2,4-D is profoundly affected by the manner in which it is formulated. Until fairly recently, 2,4-D acid itself was regarded as being ineffective as a herbicide, and therefore the chemical is usually applied in the form of a water soluble salt such as the sodium, triethanolamine, or triethylamine salts, or as an emulsified ester in water or as an oil solution of an ester. Herbicidal activity is least with the water soluble salts but the selectivity is greatest. In general, the greatest herbicidal activity is exhibited by solutions of esters in oils although there are notable exceptions to this in cases where a contact herbicidal action takes place which may prevent the further translocation of the herbicide.

The mode of action of hormone herbicides has been the subject of intensive enquiry at numerous centres throughout the world and although a great deal has been learned which has proved valuable in the more effective use of these compounds, the actual cause of the herbicidal properties of 2,4-D and allied products remain obscure.

The selective action of the synthetic hormone herbicides is their outstanding characteristic and, as in the case of the dinitro compounds, is largely a function of the plant itself due to physiological differences, to morphological differences as they affect wetting and retention, and to differential absorption. In addition, and differing in this respect from the dinitros, translocation differences are of great importance in determining the activity and selectivity of hormones herbicides.

Physiological differences between individual plants and between plants of the same species at different growth stages and under different environmental conditions are major factors in determining the response to hormone herbicides, and the effective use of these products depends upon a painstaking correlation of the response of individual weed and crop plants at varying stages of growth and under a wide range of environmental conditions.

Translocation of hormone herbicides is intimately associated with the plant species and the stage of growth. Absorption and translocation of 2,4-D upwards from the root system takes place rapidly and most plants are very much more sensitive to applications to the roots than to the aerial portions. Absorption of ester forms by leaves takes place more rapidly than the absorption of water soluble salts, but translocation is frequently slower. Movement of hormone herbicides is through the phloem and takes place usually in the direction of movement of soluble sugars from the point of storage or synthesis to the points of utilization. It is for this reason that maximum efficiency is obtained with most herbaceous perennial weeds, at, or immediately before, flowering.

There appears to be general agreement on the chemical structure of hormone herbicides. They consist of essentially a substituted ring system such as benzene, and an oxycarboxylic acid, or derivative, capable of being easily converted to carboxylic acid.

The nature and position of substituents on the phenyl group determine the activity of the compound as a herbicide. Halogenation in the 4 position confers the greatest herbicidal activity, whereas the 2-chlorphenoxyacetic acid has less than one-tenth of this activity. If a second chlorine or methyl group is substituted in the 2 position, the activity is further enhanced. Tri-substitution causes a profound change in the properties of the molecule, thus 2,4,5-trichlorphenoxyacetic acid on most common weed species is, in general, less active than 2,4-dichlorphenoxyacetic acid, yet it exhibits an abnormally increased activity towards others. 2,4,6-trichlorphenoxyacetic acid on the other hand exhibits practically no herbicidal activity whatever. It has been shown that substitution in both the 2 and the 6 positions, are accompanied by a loss of activity and recent studies on the action of plant growth regulators with respect to enzyne kinetics indicate that they may actually compete with and neutralize the effect of other auxins including 2,4-D. Replacement of the phenoxy ring with a naphthoxy ring is accompanied by an almost complete loss of activity. α-and β-chlornaphthoxyacetic acids are at best, weak contact herbicides. A carboxyl group is essential to the herbicidal activity of phenoxyacetic acid. The hydroxyl group is the carboxyl radicle may be replaced to form salts, esters or amides, without loss of activity.

The commercial use of hormone herbicides stems from the publication of Zimmerman and Hitchcock in 1942 in which the growth regulating properties and acute toxicity of 2,4-D to plant life were first described. Initial development was retarded by the war and it was not until 1945, that 2,4-D was used commercially to any extent; since that time the production and use of hormone herbicides have risen dramatically. Their outstanding field of use has been for the control of weeds in cereal crops and in pastures. The introduction of 2,4,5-T has extended the field to include the control of blackberry, brambles and scrub species. The control of mesquite in the U.S.A. with 2,4,5-T is an achievement which is proving of tremendous economic importance to the cattlemen of the central southern States, yet it may be overshadowed by the contribution which can be made in the control of Brigalow scrub in Queensland and northern New South Wales.

The end of the development is not yet in sight, and already the benefits to primary industry following the introduction of the hormone herbicides have been of very great importance and are destined to be of still greater significance as the demands made on our land resources continue to grow.

Soil Sterilants

Soil sterilants are a class of herbicides of rapidly growing importance. Many

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There appears to be general agreement on the chemical structure of hormone herbicides. They consist of essentially a substituted ring system such as benzene, and an oxycarboxylic acid, or derivative, capable of being easily converted to carboxylic acid.

The nature and position of substituents on the phenyl group determine the activity of the compound as a herbicide. Halogenation in the 4 position confers the greatest herbicidal activity, whereas the 2-chlorphenoxyacetic acid has less than one-tenth of this activity. If a second chlorine or methyl group is substituted in the 2 position, the activity is further enhanced. Tri-substitution causes a profound change in the properties of the molecule, thus 2,4,5-trichlorphenoxyacetic acid on most common weed species is, in general, less active than 2,4-dichlorphenoxyacetic acid, yet it exhibits an abnormally increased activity towards others. 2,4,6-trichlorphenoxyacetic acid on the other hand exhibits practically no herbicidal activity whatever. It has been shown that substitution in both the 2 and the 6 positions, are accompanied by a loss of activity and recent studies on the action of plant growth regulators with respect to enzyne kinetics indicate that they may actually compete with and neutralize the effect of other auxins including 2,4-D. Replacement of the phenoxy ring with a naphthoxy ring is accompanied by an almost complete loss of activity. α-and β-chlornaphthoxyacetic acids are at best, weak contact herbicides. A carboxyl group is essential to the herbicidal activity of phenoxyacetic acid. The hydroxyl group is the carboxyl radicle may be replaced to form salts, esters or amides, without loss of activity.

The commercial use of hormone herbicides stems from the publication of Zimmerman and Hitchcock in 1942 in which the growth regulating properties and acute toxicity of 2,4-D to plant life were first described. Initial development was retarded by the war and it was not until 1945, that 2,4-D was used commercially to any extent; since that time the production and use of hormone herbicides have risen dramatically. Their outstanding field of use has been for the control of weeds in cereal crops and in pastures. The introduction of 2,4,5-T has extended the field to include the control of blackberry, brambles and scrub species. The control of mesquite in the U.S.A. with 2,4,5-T is an achievement which is proving of tremendous economic importance to the cattlemen of the central southern States, yet it may be overshadowed by the contribution which can be made in the control of Brigalow scrub in Queensland and northern New South Wales.

The end of the development is not yet in sight, and already the benefits to primary industry following the introduction of the hormone herbicides have been of very great importance and are destined to be of still greater significance as the demands made on our land resources continue to grow.

Soil Sterilants

Soil sterilants are a class of herbicides of rapidly growing importance. Many

of the compounds with which we are familiar as contact or translocated herbicides have also proved effective when applied to the soil. The use of 2,4-D for pre-emergence weed control in large seeded crops, such as maize and sweet corn, has become standard practice in the U.S.A. An important development in Australia has been the use of 2,4-D as a pre-emergence treatment in the planting of sugar cane where, under favourable conditions, freshly planted cane remains weed free for many months.

Soil sterilants may be either temporary or permanent. Temporary soil sterilants include fumigants such as methyl bromide, ethylene dibromide, chlorpicrin and carbon disulphide, the effect of which seldom lasts more than two or three days. Owing to their high cost, toxicity and difficulty of handling, the use of these compounds is restricted to the treatment of nursery bed and glass house soils but in addition to their herbicidal action, they are also valuable as fungicides and soil insecticides.

Temporary Soil Sterilants

Temporary soil sterilants of major importance in agriculture include sodium trichloracetate, isopropyl-N-phenyl carbamate and isopropyl N-(3,chlorphenyl) carbamate. Promising results are also being shown by 2,4-dichlorphenoxy ethyl sulphate.

Sodium trichloracetate is an interesting example of a temporary soil sterilant, which has proved useful for the eradication of perennial grasses. It is not particularly effective against deep-rooted annual or perennial weeds. The selectivity of T.C.A. appears to be associated with the physiology of the plant species but is also very much influenced by soil texture and moisture which appear to determine the depth to which penetration in herbicidal concentrations can occur.

A mode of action suggested by the well-known protein coagulant properties of trichloracetic acid is the uptake of the compound by the root system translocation via the non-living xylem tissue throughout the plant followed by protein precipitation in the enzyme system. It is of interest to note that T.C.A. is a potent contact herbicide when applied to the foliage of plants, but that very little translocation, if any, takes place, due presumably to its toxicity to the phloem tissue. Commercial use of T.C.A. is restricted by reason of its present high cost, but it has found a valuable application in the control of the Yass river tussock and other persistent perennial grasses.

Isopropyl N-phenyl carbamate and isopropyl N(3-chlorphenyl) carbamate are compounds of great interest in that unlike the phenoxyacetic acids, they have exhibited in general a greater activity towards monocotyledons than against dicotyledons. I.P.C. possesses very high degrees of selectivity and specificity which have proved valuable for the eradication of annual grasses in leguminous crops grown for seed purposes. Chloro-I.P.C. has proved to be effective against a wider range of grasses and has found use for the control of annual grasses such as summer grass (*Digitaria* sp.) in broad leafed crops.

The selectivity shown by these compounds is very marked and is largely a function of the physiology of individual plant species; a highly significant correlation between molecular configuration and herbicidal activity has been shown to exist. The effect of the carbamates is to inhibit the formation of chlorophyll in the germinating seeds and seedlings of susceptible plants. A suggested mode of action is the modification of chromosomes with respect to the genes responsible for the control of chlorophyll production.

Commercial acceptance of these compounds has been somewhat retarded by the stringent conditions necessary for successful use, the high degree of speci-

ficity shown and by the variable results that have been reported. Further research into this group of compounds with particular reference to the development of derivatives of lower volatility, a suggested factor responsible for variable results, and the use of a number of compounds in combination to achieve a desired degree of selectivity, will undoubtedly yield new herbicidal products of great value.

Permanent Soil Sterilants

Permanent soil sterilants hitherto have been confined to inorganic poisons such as arsenical, chlorate and boron compounds. The introduction of chlorphenyl dimethyl urea and more recently of phenyl dimethyl urea, marks a significant advance in the development of soil sterilants in that these compounds are non-poisonous, non-inflammable in use, and, with larger scale manufacture, may well compete economically with the inorganic sterilants.

Economic Aspects

The contribution of organic herbicides to primary industry in Australia and the total economic loss as a result of weed infestation in crops and pastures has not been been fully assessed. In America, however, Dr. Lovvron, then Director of Weed Control Research in the U.S.D.A., has estimated that losses as a result of weed competition exceed $5,000,000,000. More than half this loss could have been prevented by the application of existing knowledge.

The demand made by weeds for water and soil nutrients often exceeds that of the crop plant, as an example, it has been shown that wild mustard, a common weed in cereal crops, requires twice as much nitrogen, and phosphorus, three times as much potash and four times as much water as a vigorous oat plant. Numerous examples could be quoted of the increases in crop yields following the application of weed control chemicals, but the current production and sales of herbicides are sufficient proof of the value which primary industry places on these products.

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RETURNS FROM SOIL CONSERVATION ON PART OF THE FARM

By I. MOLNAR

Although the maintenance of soil fertility and encouragement of erosion preventive practices is the aim of any soil conservation programme, the greatest immediate task is the rehabilitation of already eroded land. In the water-eroded areas of Victoria this rehabilitation often includes the use of mechanical works with or without orthodox agricultural measures. In these areas most of the mechanical works have been carried out in grazing paddocks. Such works seldom embrace the whole farm and the production of paddocks can usually be measured by stocking rates only.

Among the farmers whose farms were surveyed by the Soil Conservation Authority of Victoria prior to 1950, 183 were questioned in 1952 to obtain stocking records for paddocks where a substantial portion of the acreage was contour worked. Although 47% of the farmers responded to the questionnaire, useful records were available on nine farms only, and these records referred to contour furrowed paddocks only. For contour banked paddocks satisfactory records could not be found, while those with diversion banks, grassed chutes and concrete structures were ignored because the determination of the area benefiting from such works is seldom possible.

This paper is based on the somewhat meagre paddock records which are the only procurable data for Victoria. Although these records do not permit the drawing of any hard and fast rules they indicate the effect of soil conservation practices under certain conditions. In this paper comparisons of production, assessed as stocking rates, are shown before and after contour furrowing, the production of contour furrowed paddocks is compared with those not contour furrowed, and the effect of contour furrowing on adjacent cultivated land is also shown. The production of these paddocks is then contrasted with the costs of soil conservation works and measures applied.

Production

Paddock History

The nine selected contour furrowed paddocks are located in areas of 19 in.-26 in. average annual rainfall. Before contour furrowing two paddocks had been topdressed with superphosphate for some years, while the others, as far as is known, had not been topdressed. Some other details for these paddocks are shown in Tables I and II.

The origin of erosion varied, in No. 1 paddock it was caused by mechanized units of the Army which used the area as training ground, in No. 9 by gravel stripping, and in the others it was the result of overstocking. In some paddocks overstocking was accompanied by other causes: in No. 3 by rabbits, and water runoff resulting from overgrazing on the neighbour's paddock, in No. 4 by salting, and in No. 5 by overgrazing on the neighbour's paddock.

Stocking Rates and their Limitations

Table III shows the computed rates of stocking. Stocking rates were computed by using the conversion factors of Lang

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TABLE I.

Showing for each of the nine contour furrowed paddocks the nearest main township and its average annual rainfall, area of paddock contour furrowed and year of furrowing.

Paddock No.	Nearest main township and av. annual rainfall		Area of paddock	Approximate area contour furrowed	Year of contour furrowing
		inches	(acres)	(acres)	
1	Seymour	22	600	300	1947-48
2	St. Arnaud	19	1,740	500*	1945-46
3	Benalla	26	400	200	1948
4	Seymour	22	120	50	1947
5	Dunolly	20	420	200	1949
6	Ararat	24	630†	550	1949
7	Ararat	24	300	200	1949
8	Benalla	26	280	110	1949
9	Colbinabbin	19	15	10	1950

*Part of this acreage in adjoining paddock.
†Includes 60 acres timbered area.

et al. (1952) and correcting for hand-feeding. The stocking rates were calculated for all those years for which sufficiently reliable records were available, except the years in which the paddock was (i) grazed in conjunction with another paddock, (ii) used as a "holding paddock" during shearing, (iii) wholly or partly cropped or (iv) affected by considerable change in its rabbit population.

No adjustment of the stocking rates for variations in the seasonal conditions was practicable because of the different grazing practices followed on different farms or paddocks. If, for instance, a paddock is grazed in successive years with a constant number of stock, the result is that in some years the animals have inadequate food and in other years more than they can eat. If alternatively, it is grazed with different numbers of stock in different years, it will be grazed lightly following the years it was eaten out. Those farmers who stock their paddocks according to the available herbage must be relatively few, because the buying and selling of stock according to the available herbage is seldom practicable. For these reasons the stocking rates, shown in Table III, are contrasted only with departures from the annual mean rainfall.

In spite of these shortcomings the stocking rates of each of the paddocks can be compared over the selected years because the farmers concerned had some experience with the adverse effects of excessive stocking and these paddocks, with the exception of No. 2, had shown no readily recognisable signs of further erosion when visited in 1952. Hence it is reasonable to assume that they were not overgrazed in the years following contour furrowing and that the animals kept on them had adequate feed.

Production before and after Contour Furrowing

In paddock No. 8 contour furrows without any additional measures could not maintain the pre-furrowing rates of stocking without further erosion hazard. Contour furrows were adequate, how-

TABLE II.

Showing for four contour furrowed paddocks the area topdressed with superphosphate and rates of application per acre.

Heavy type indicates first application.

Paddock No.		Area top-dressed and rate of application												
		1937	1938	1940	1945	1946	1947	1948	1949	1950	1951		1952	
3	Acres	**350**	350	350	—	—	—	—	350	350	350		—	
	lb/acre	**90**	90	90	—	—	—	—	90	90	90		—	
4	Acres	—	—	—	**120**	120	120	50*	50	50	50		50	
	lb/acre	—	—	—	**90**	90	90	112	112	112	112		112	
5	Acres	—	—	—	—	—	—	—	**200**	200‡	200†		—	
	lb/acre	—	—	—	—	—	—	—	**112**	112	112		—	
6	Acres	—	—	—	—	—	—	**160**	160	160	160	140	160	100
	lb/acre	—	—	—	—	—	—	**183**	183	183	90	183	124	183

*1 lb. subterranean clover per acre broadcast on 40 acres with superphosphate.
†3 lb. subterranean clover and 2 lb. Wimmera Rye grass per acre broadcast on 50 acres with superphosphate.

‡3 lb. subterranean clover and 2 lb. Wimmera Rye grass per acre broadcast on 80 acres with superphosphate.

TABLE III.

Showing for eight contour furrowed paddocks the computed annual rates of stocking as acres per dry Merino sheep, and departure from average annual rainfall in inches.

Paddock No.	1933	1935	1944	1945	1946	1947	1948	1949	1950	1951	1952
	Stocking rate, acres per dry Merino sheep										
1						5.1	1.9	2.8	1.3	1.8	—
2	2.7	2.8	—	—	3.3	3.4	2.6	—	2.6	—	—
3	—	—	—	1.0*	1.1	1.0	1.0	1.1	1.0	1.0	—
4	—	—	—	—	—	1.1	0.5	0.5	0.7	0.5	0.5
5	—	—	—	—	—	—	1.1	0.7	0.9	1.2	1.1
6	—	—	—	—	—	—	1.6*†	1.2†	1.2†	1.4†	2.1†
7	—	—	1.6	1.8	1.5	1.5	1.7	1.8	1.8	1.8	1.8
8	—	—	—	—	1.3	1.5	1.2	0.8	1.3	2.2	2.0
	Departure from av. annual rainfall, inches.										
1	—	—	—	—	—	+3	0	+6	+8	+6	—
2	+9	—2	—	—	+4	+6	—3	—	+8	—	—
3	—	—	—	—	+1	+6	—2	0	0	—2	—
4	—	—	—	—	—	+3	0	+6	+8	+6	—
5	—	—	—	—	—	—	—4	+1	+4	+2	+2
6	—	—	—4	—4	+9	+9	—2	—2	+2	+6	+6
7	—	—	—	—	+1	+6	—2	0	0	—2	+6
8											

†Not based on records.
*Based on acreage free of timber.

ever, to maintain the pre-furrowing levels of stocking in paddocks Nos. 1, 2 and 7, though in paddock No. 2 the furrows have retarded but have not checked erosion. Stocking rates were only maintained in No. 3 paddock where superphosphate applications and contour furrowing barely maintained stocking rates, this was because rabbit control was inadequate. However, the same practices with rabbits kept in check, gave a high rate of stocking in paddock No. 4. Although there were fairly extensive improvements in paddock No. 5, it was stocked lightly to enable the establishment of subterranean clover and Wimmera ryegrass seed sown with the superphosphate. The moderate increase in stocking after extensive contour furrowing of paddock No. 6, can be ascribed to a relatively small top-dressed acreage in the earlier years, to lack of sufficient response to superphosphate applications, and to inadequate rainfall in the spring of 1951.

Production of Contour Furrowed Versus Non-eroded Paddocks

The production of the contour furrowed, seeded and topdressed No. 5 paddock compared with an adjacent non-eroded unimproved one, shows that while in No. 5 the stocking rates per dry Merino sheep were 0.7 and 0.9 acres in 1949 and 1950, respectively, the corresponding figures for the adjacent paddock were 4.4 and 4.7 acres.

A comparison of the stocking rates of a non-eroded unimproved paddock adjoining the contour furrowed and topdressed No. 6 and adjacent to the contour furrowed only No. 7 shows that while the stocking rates in the non-eroded unimproved paddock were per dry Merino sheep 1.3 acres up to 1951, they were between 1.2 and 1.4 in No. 6 paddock, and between 1.5 and 1.8 in No. 7 paddock.

Production of Cropping Land Alongside Contour Furrowed Paddocks

Excessive water run-off from paddock No. 8 developed gullies in an adjoining cultivated paddock. As a result, cultivation had to be abandoned until paddock No. 8 was contour furrowed. While out of cultivation it was stocked at a rate never exceeding 0.3 acres per sheep, but following contour furrowing the gullies were filled in 1950, and 55 acres were fallowed in the same year, yielding 24 bushels of wheat per acre. In the following year 45 acres were stubble sown to wheat and 10 acres to oats, yielding 4 and 20 bushels respectively per acre in addition to providing some grazing.

Gravel stripping in paddock No. 9 brought about gullying in an adjoining cultivation paddock of 53 acres, and sheet erosion in another adjoining paddock of 32 acres, making the latter one suitable for a horse paddock only, but not safe for cultivation. Contour furrowing in paddock No. 9 not only healed the gully but also made possible the cultivation of the sheet eroded previously uncultivated paddock which yielded 9 bags of wheat per acre in 1951 and 9 bags of oats per acre in 1952.

Costs

In the examples quoted, the soil conservation works and measures and their effect on production were confined to portions only of the farms concerned. Therefore, for the computation of the costs involved the following assumptions were made:—

1. The whole of the partially contour furrowed paddock benefited from the work.
2. Expenditure was at the following rates:—

   (i) contour furrowing per acre, £1.

   This figure of £1 per acre is charged by a contractor in Victoria who has been contour furrowing in this State over considerable areas. This amount does not include costs of the surveyor's work because this is provided free of charge in Victoria. Some cost records indi-

cate, however, that if the work is done with the farmer's own machinery then the cost of labour and fuel per acre is likely to be less than 10 shillings. In this figure labour is accounted for at basic wage rates and fuel at current prices, but depreciation and interest on the machinery are not included. The working life of a tractor is about 10,000 hours and contour furrowing (including marking of the surveyed lines) can be done with normal farm equipment at the rate of about 2 acres per tractor hour. Therefore, depreciation on the cost of the tractor and plough, say £1,000, which can be attributed to contour furrowing would be about 1 shilling per acre. In other words, cost of contour furrowing is over-estimated at the rate of £1 per acre if the work is performed with the farmer's own machinery.

(ii) superphosphate, £14 per ton on farm.

(iii) subterranean clover seed, 4/6 per lb. on farm.

(iv) Wimmera rye grass seed, 1/6 per lb. on farm.

(v) spreading of superphosphate, 5 shillings per acre.

On rough ground about 4 bags of superphosphate can be spread in an hour with a "spinner" at the rate of 1 cwt. per acre. At basic wage rates this means about 3 shillings per acre for two men. To eliminate any difference in the costs due to differences in managerial practices, it was assumed that 4 cwt. of superphosphate was spread out per acre in one application on all the paddocks considered. Allowing for slightly slower work with the spreading of 4 cwt. than 1 cwt. per acre, 4 shillings per acre was allotted for labour and 1 shilling per acre for fuel and maintenance. However, no depreciation and interest on the value of machinery used in spreading the superphosphate was taken into account. This would have been unrealistic. Depreciation would have to be based on the relative proportion of the areas top-dressed for other purposes. Even if the acreage of the annually improved pastures had been known any depreciation would be greatly affected by the extent of the annual pasture improvement programme. Furthermore, much less is known of the working life of "spinner" distributors than of tractors.

3. Costs were based on the total acreage of the contour furrowed paddock only.
4. Costs of subdivisional fences were disregarded.
5. Any difference in the cost of management before and after conservation works was ignored, though the cost of management may vary substantially with soil conservation works, e.g., rabbit control when gullies are filled in.
6. No machinery was specially purchased for reclamation works only.
7. Interest on the capital invested in the farm, land tax and rates were disregarded, though the last two items may change with advanced erosion.

The costs shown in Table IV are based on the foregoing assumptions. No attempt was made to amortize the costs since the useful life of contour furrows under various conditions in Victoria is not known.

Discussion and Conclusion

With the exception of No. 4, none of the contour furrowed paddocks could be stocked safely at a rate greater than in the years which preceded the ploughing of furrows. After contour furrowing these rates of stocking were considered

TABLE IV.

Assumed safe rate of stocking and costs of the applied conservation practices for each contour furrowed paddock.

No. of paddock	Acres per dry Merino sheep	Costs per acre to the nearest shilling	Total costs to the nearest £10
1	2.0	10	300
2	less than 2.6	6	500
3	1.0	44*	880*
4	0.5	81	490
5	1.0	37	780
6	1.4	55	1,700
7	1.8	13	200
8	2.2	36†‡	200†
9	practically nil	14	10

*does not include costs of topdressing in 1937, 1938, 1940.
†includes £90 allotted for bulldozing gullies.
‡based on 110 acres only.

safe on most of the paddocks. The costs involved were substantial in some paddocks, but in these instances stocking rates could have been heavier except for lack of rabbit netting as in paddock No. 3, for preference of pasture establishment to increased stocking as in paddock No. 5, or for failure of establishing subterranean clover as in paddock No. 6. Bulldozing of the gullies raised the costs for paddock No. 8. In addition, in none of the paddocks have adequate subdivisional fences been erected and in most of them no fences were erected at all, though this would have been desirable in all instances. With adequate subdivisional fences the results could have been quite different.

When assessing the value of the soil conservation practices consideration has to be given also to the benefits derived from them not only in the paddock directly involved, but also on the land-use potential of adjacent paddocks. Paddocks No. 8 and 9 illustrate this point.

The final test to the costs of soil conservation is, however, the prevention of capital loss on account of erosion. The writer found (unpublished data) that, in the Coleraine area, if the size and soil class of a land is kept constant, the loss in value (measured by the prices paid by buyers of land) which can be attributed to a difference of one erosion class is estimated at about £1/10/- per acre. Corresponding figures in the areas where the nine contour furrowed paddocks are located are not known. If paddock No. 4 is ignored (where carrying capacity is high as a result of extensive improvements) and the Coleraine figures are used as a rough guide, then even the highest of the quoted costs would have been recovered if it prevented a further deterioration of two erosion classes. It has to be borne in mind that the deterioration of land from one erosion class to another is often rapid and there can be considerable capital loss on this account over a relatively short period. However, before any predictions can be made regarding the profitability of soil conservation practices to the individual, many more examples will be necessary.

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(*Received for publication June* 17, 1954).

PROBLEMS IN TREE REPLACEMENT

II. THE EFFECT OF CERTAIN METHODS OF MANAGEMENT ON THE NEMATODE FAUNA OF AN ORCHARD SOIL

By R. C. COLBRAN

Summary

The root-lesion nematode *Pratylenchus coffeae* Zimmerman remained infestive in cans of moist soil free of plant growth for 8 months.

The population of *P. coffeae* in field plots from which infested apple trees had been removed was maintained at a high level when the area was cropped with tomatoes or allowed to revert to a volunteer vegetation which contained *Rumex acetosella* L. as a dominant species.

In a field experiment, sawdust mulching for 9 months to suppress plant growth resulted in a considerable reduction of the soil population of *P. coffeae*, *Paratylenchus macrophallus* (deMan) Goodey and *Trichodorus* sp.

Introduction

In an earlier paper (Colbran, 1953), it was reported that the root-lesion nematode *Pratylenchus coffeae* Zimmerman was widespread in the orchard soils at Stanthorpe and was responsible for the unsatisfactory growth of apple seedlings.*

The procedure of replanting an unproductive apple orchard with stone or pome fruits has frequently proved unsatisfactory and for this reason old orchard ground is commonly used either for the production of vegetables or alternatively it is allowed to spell for several years under a volunteer vegetation.

The work reported in this paper was carried out to determine the changes occuring in the nematode population of the soil under these two systems of management and also under a sawdust mulch. The sawdust mulch treatment was included because a preliminary experiment on the longevity of *P. coffeae* in moist soil free of plant growth had indicated that mulching might be an effective means of reducing soil infestations of this species.

*Since the preparation of that paper, Sher and Allen (1953) have revised the genus **Pratylenchus** and included **P. musicola** (Cobb) Filipjev and **P. mahogani** (Cobb) Filipjev as synonyms of **P. coffeae**.

Experimental

The longevity of P. coffeae in moist soil in the absence of host plants

A quantity of moist soil infested with *P. coffeae* was passed through a 4-mesh sieve to remove larger pieces of infested roots and was then thoroughly mixed and placed in approximately equal quantities in six metal cans $3\frac{1}{2}$ in. in diameter and $8\frac{1}{2}$ in. in length. These were provided with lids and, after holes had been made in the sides to provide adequate aeration, they were embedded upright in the orchard to a depth of 6 in. During the first month of the experiment, a layer of sawdust on the soil served to suppress the growth of volunteer weeds.

At the start of the experiment and at monthly intervals thereafter, the soil in each can was thoroughly mixed and two 40g samples taken from each. Each sample was placed in a 4 in. Petri dish together with three linseed seeds which had been germinated on moist filter paper. The radicle at this stage was $\frac{1}{4}$-$\frac{1}{2}$ in. in length. A piece of moist absorbent paper was placed in the lid of each dish which was kept under a bell-jar for 4 days. The seedlings were then

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washed free of soil stained in boiling acid fuchsin lactophenol and partially cleared in plain lactophenol. The adults and larvae of *P. coffeae* within the roots were counted under a microscope at 50X and the total number in the 36 linseed plants taken as a measure of the soil population.

The validity of the above method for estimating the number of adults and larvae of *P. coffeae* in 40g samples of soil was tested by repeating the planting and counting procedure with a number of samples after the first series of linseed plants had been removed. These tests showed that 90-100% of adults and larvae other than first stage, which were found in the roots, occurred in the first series. Of the few nematodes in the second series, the majority were first stage larvae which had probably hatched from eggs present in the soil at the time of the first count. There seems every justification for regarding the counts obtained by this method as a close approximation to the actual number of adults and larvae present in the soil sample.

The composition of the nematode fauna in relation to soil management

An area from which apple trees grown as cordons at 5 ft. x $3\frac{3}{4}$ ft. had been removed during the winter of 1951 was divided into 9 plots each 7 ft. x 7 ft. with cultivated strips 2 ft. wide between adjacent plots. The use of 6 in. x 1 in. hardwood boards around the plots served to prevent nematodes being introduced to the plots per medium of run-off from higher ground.

The following treatments were applied to the plots on October 20, 1952:

1. Three inches of sawdust evenly distributed over the plot after plant growth had been destroyed by cultivation. Plots 1, 2, 3.

2. Twelve tomato plants set out in the plot and weed growth kept at a minimum. Plots 4, 5.

3. Volunteer weed growth left unchecked. The vegetation in these plots was: Plot 6, *Eleusine indica* (L) Gaertn. (crowsfoot grass), Plot 7, *Eleusine indica* and *Digitaria adscendens* (H.B.K.) Henrard. (summer grass), Plot 8, *Digitaria adscendens* and *Rumex acetosella L.* (sorrel), and Plot 9, *Digitaria adscendens* and *Rumex acetosella.*

In July, 1953, the composition of the nematode fauna was examined. Five soil samples each weighing 80g were taken from the top 3 in. in each plot and the nematodes removed by the Baermann funnel technique. The soil was placed in frames similar to those used by Christie and Perry (1951a) and the nematodes drawn off after $7\frac{1}{2}$ hours. They were killed by gentle heat, fixed in formalin acetic acid and counts made of the different species in each sample. Although the numbers obtained by this method are far from complete as a measure of the total number of nematodes in each sample, it is considered that the standardization of the time of extraction and the use of five samples per plot offers a sound basis for the comparison of the nematode populations in the different plots.

Results

The numbers of adults and larvae of *P. coffeae* found within the 36 linseed plants at monthly intervals are shown in Table I.

TABLE I.

Decrease in infestivity of P. coffeae in moist soil free from host plants

Date of count 1952	No. of *P. coffeae* in 36 linseed roots after 4 days
April 9	210
May 9	215
June 9	195
July 9	166
August 9	122
September 9	89
October 9	22
November 9	4
December 9	0

The rate at which the infestivity of *P. coffeae* decreased was, at first, rather slow but tended to increase from July to December. No nematodes were found in the 36 linseed roots at the time of the December count indicating that few, if any, viable parasites remained in the soil at this time.

The composition of the samples from the field plots is presented in Table II. A number of nematode species were of infrequent occurrence and, as they have no recognized economic importance, have been grouped as "miscellaneous". This includes *Prismatolaimus intermedius* (Butschlii) deMan, *Panagrolaimus rigidus* (Schneider) Thorne, *Plectus cirratus* Bastian, *Eucephalobus oxyuroides* (de-Man) Steiner, and *Wilsonema auriculatum* Cobb. The species of *Tylenchus* present included *T. filiformis* Butschlii, *T. agricola* deMan and *T. costatus* deMan.

A saprophyte *Acrobeloides butschlii* (deMan) Steiner and Buhrer was present in all plots and was usually the predominant species. *Pratylenchus coffeae* was present in large numbers in the tomato plots and in weed plots 6 and 7, in much smaller numbers in weed plots 4 and 5 and practically absent under sawdust mulches. The ectoparasites *Paratylenchus macrophallus* (deMan) Goodey and *Trichodorus* sp. were absent from the mulched plots but present in quantity in several of the other plots. *Aphelenchoides parietinus* (Bastian) Steiner and *Aphelenchus avenae* Bastian, although not obligate parasites, were fewer in the mulched plots than in plots where plant growth was present. The same held true for the species of *Deladenus* and *Ditylenchus*.

Discussion

Pratylenchus coffeae is regarded as an obligate plant parasite so that a reduction in the soil population is to be expected in the absence of suitable host plants. The decrease in numbers under these conditions is accelerated by the activities of a large number of natural enemies represented by protozoa, mites, oligochaetes, bacteria, fungi and predatory nematodes (Chitwood and Oteifa, 1952). In the course of these investigations, only one nematode species has been observed in the process of destroying *P. coffeae*, viz., *Aphelenchoides tenuicaudatus* (deMan) Goodey. The following genera which contain species reported as predators on other nematodes are re-

TABLE II.

Nematodes in treatment plots on old orchard soil.

Nematode species	No. of nematodes per 400g soil by extraction for 7½ hours in Baermann funnels								
	Sawdust Mulch			Volunteer Weed Growth				Tomato Crop	
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9
Pratylenchus coffeae	4	9	7	22	28	644	156	766	570
Trichodorus sp.	0	0	0	0	42	10	0	65	110
Paratylenchus macrophallus	0	0	0	2	0	724	56	0	1
Tylenchus spp.	128	65	323	366	550	304	198	695	240
Aphelenchus avenae	1	7	13	0	28	8	4	22	84
Aphelenchoides parietinus	11	15	32	96	527	100	186	341	176
Deladenus sp.	0	0	0	18	16	16	6	24	0
Ditylenchus sp.	0	0	0	0	83	8	18	0	0
Eucephalobus sp.	99	1041	757	604	1456	526	1380	2806	1772
Dorylaimus brevidens	1	1	0	0	19	30	0	206	4
Rhabditis monhystera	3	1	9	0	28	36	48	25	14
Miscellaneous	17	6	36	22	36	0	26	41	8
Plot Totals	**264**	**1145**	**1177**	**1130**	**2813**	**2406**	**2078**	**4991**	**2979**

presented in orchard soils at Stanthorpe —*Mononchus, Aphelenchoides, Dorylaimus, Nyolaimus, Diplogaster* and *Tripyla*. Some of these species may exercise a measure of control against *Pratylenchus coffeae*.

The effect of the system of management on the nematode fauna of the soil was well marked. *P. coffeae* was present in small numbers after the plots had been under a sawdust mulch for 9 months. On the other hand, the population was very high where tomatoes had been grown and a similar effect might be expected if other suitable hosts, e.g., beans or peas had been used. Where the land was spelled under volunteer vegetation there was a much larger infestation in plots 6 and 7 than in plots 4 and 5 and this appeared to be attributable to the presence of *Rumex acetosella* (sorrel) in the former. The roots of this perennial were found to be heavily infested with root-lesion nematodes whereas the grasses *Eleusine indica* and *Digitaria adscendens* were only lightly infested and, in addition, are summer annuals. The survival of *P. coffeae* in land under volunteer vegetation at Stanthorpe appears to be due in part to the prevalence of sorrel.

The genus *Tylenchus* was well represented in all plots but it was noted that *T. costatus* and *T. agricola* were infrequent in the mulched plots. These two species are considered as phytoparasitic as the former has been found to reproduce in the roots of *Lupinus angustifolius* L. and *Trifolium repens* L., and the latter in the roots of several apple rootstocks at the C.S.I.R.O. Field Station, Applethorpe. The ectoparisites *Trichodorus* sp. and *Paratylenchus macrophallus* were absent under the sawdust mulch. A species of *Trichodorus* is responsible for the "stubby-root disease" of tomatoes, sweet corn and lima beans in the U.S.A. (Christie and Perry, 1951b) and the large numbers in the tomato plots suggest that the species present at Stanthorpe may be of some importance. The food habits of *Deladenus* sp. and *Ditylenchus* are unknown but their absence from the mulched plots suggests that they are dependent on the presence of living plants.

The low population of plant parasitic nematodes under the sawdust mulch indicates that mulching designed to suppress the growth of plants offers a method of preparing infested orchard soil for replanting. There are difficulties involved in the collection and distribution of sawdust for large areas and more convenient methods of maintaining a bare fallow without deleterious effects on soil structure may be found in the future.

Acknowledgment

The author is indebted to the late Dr. T. Goodey and to Dr. J. B. Goodey, of Rothamsted, for examining nematode material, and also to L. A. Thomas, C.S.I.R.O., Stanthorpe, for valued advice during the course of the investigations.

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DESIRABLE COMBINATIONS OF CHARACTERS IN F_1 HYBRID TOMATOES FOR THE GLASSHOUSE

By J. E. GILES

Summary

Hybridization experiments with glasshouse tomatoes were conducted in the Mildura district to test whether the desirable characters of pairs of varieties could be combined together in F_1 hybrids. Two of these, South Australian Dwarf (C strain) x Vetomold and Tatinter x Vetomold, combined high yields, good growth habit, high percentages of smooth first-grade fruit, early ripening and resistance to leaf-mould. Yields of the hybrids did not differ significantly from those of the parents so that heterosis did not accompany these combinations of characters.

Introduction

A number of tomato varieties and crossbreds have been grown in the experimental glasshouse of the C.S.I.R.O. at Buronga, N.S.W., near Mildura, Victoria, to test their suitability for district conditions. As fusarium-wilt and leaf-mould are serious glasshouse diseases in some seasons, two fusarium-wilt resistant crossbreds (Nos. 69 and 28) developed at the Merbein Research Station for field conditions, and the leaf-mould resistant variety, Vetomold, were included. Many investigators have reported the advantages of utilizing the hybrid F_1 generation in various crops. It was decided to test whether the F_1 progeny derived from these tomato varieties and crossbreds would prove superior to their parents.

Methods

Plants were grown in 5 rows each 2 ft. 3 in. apart with 1 ft. between plants in a Wentworth loam soil (Marshall and Walkley 1937), in an unheated commercial glasshouse 100 ft. long, 15 ft. wide and ranging from 3 ft. 6 in. to 6 ft. 6 in. in height. A guard row was established on each side of the area to prevent side effects. The layout consisted of a 5 x 5 Hyper-Graeco-Latin square (Yates 1937) in which each whole plot was split into three sub-plots, thus enabling 15 lines to be compared by arranging them in suitable combinations. Each sub-plot contained six plants. The design is described more fully in a separate paper (Birtwistle 1954). In 1950 seedlings were transplanted on the 26th April. There were 14 lines which included 8 parents and 6 F_1 hybrids, one variety being repeated to complete the layout. In 1951 transplanting was done on 14th May. The characteristics of the parental varieties are given in Table I.

Data obtained included total and first-grade yields, average fruit weight, mean maturity period, and ratings for resistance to leaf-mould infection. Yields were recorded at each picking and all sound fruit which weighed 2 oz and over was classed as first-grade and weighed separately. Average fruit weight was determined by counting and weighing all fruit harvested during the season. Fruit quality was noted in each variety and hybrid.

The mean maturity period (which is considered to give an indication of earliness of ripening) was determined on each of the parental varieties and F_1 hybrids for each season as follows:—

The weight of fruit was recorded for each date of picking. For each picking date the weight of fruit in pounds was multiplied by the number of days from

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TABLE I.

Characteristics of eight Tomato Varieties and Selections.

Varieties and Selections	Bush Type	Shape and Size of Fruit	Remarks
S.A. Dwarf (M & C strain)	Dwarf	Flat, rough and large	These and other strains of this variety are favoured by most growers
69 (Rouge de Marmonde x Pan America) x Tatura Dwarf Globe	Dwarf	Round, smooth, medium to small	Fusarium-wilt resistant
28 (Tatinter x Pan America)	Dwarf	Round, smooth, medium to small	Fusarium-wilt resistant
Tatinter	Dwarf	Flat, rough, medium	Favoured by some growers. A popular field variety in some districts
Victorian Dwarf	Dwarf	Semi-flat, fairly smooth, medium	Produces fruit considered desirable with regard to both size and shape
Vetomold	Medium	Round, smooth, medium to small	Resistant to leaf-mould
Sioux	Medium	Round, smooth, fairly large	Cluster bunch type. Generally produces heavy crop

Note: All these varieties and selections are indeterminate in growth.

transplanting to picking. The products were added together and their sum divided by the total in pounds.

At the end of the 1951 season an infection of leaf-mould occurred and ratings for resistance to infection on an 0 to 10 scale were recorded on all plants. No trouble from fusarium-wilt was experienced in any of the plantings.

Results

Yields

The yield results in Table II show that Vetomold and Sioux produced higher total yields than the other parental varieties in both seasons. Although South Australian Dwarf (M strain) was slightly lower in total yield, its yield of first-grade fruit was comparable to the above two varieties. The two fusarium-

TABLE II.

Yield, Fruiting and Disease Resisting Characteristics of eight Tomato Varieties and eleven F_1 Hybrids.

	Yields (lb/plant)				Av. Fruit Weight (ounces)		Mean Maturity Period (in days)		Ratings 0-10 for Resistance to leaf-mould Infection 1951 0—Dead plant 10—Healthy Plant
	1950		1951						
	Total	First Grade	Total	First Grade	1950	1951	1950	1951	
S.A. Dwarf (M strain)	3.03	2.60	2.99	2.52	2.85	2.44	189	193	5.7
S.A. Dwarf (C strain)	2.71	2.12	—	—	2.37	—	195	—	—
69	2.02	1.19	1.68	0.87	1.93	1.44	201	201	6.4
Tatinter	2.29	1.21	3.06	1.92	1.54	1.64	199	193	6.2
28	2.71	1.36	2.33	1.48	1.79	1.66	215	203	7.6
Vetomold	4.31	2.36	4.93	3.28	1.61	1.75	193	189	9.8
Victorian Dwarf	2.95	2.08	2.68	1.89	2.02	1.87	195	192	6.2
Sioux	3.59	2.55	4.52	3.71	2.30	2.44	199	190	7.8
F_1 Hybrids									
S.A. Dwarf (M strain) x Sioux	3.54	2.65	4.56	3.63	2.30	2.14	190	186	7.4
S.A. Dwarf (C strain) x Vetomold	3.66	2.27	5.05	3.87	2.03	2.04	187	189	8.6
69 x Sioux	2.76	1.71	—	—	1.81	—	196	—	—
69 x S.A. Dwarf (M strain)	—	—	3.08	2.04	—	1.78	—	192	6.4
Tatinter x Sioux	3.84	2.47	—	—	2.15	—	193	—	—
Tatinter x Vetomold	—	—	5.36	4.06	—	1.98	—	186	9.2
28 x Sioux	2.92	2.15	—	—	1.97	—	203	—	—
28 x S.A. Dwarf (M strain)	—	—	3.07	1.85	—	1.58	—	199	6.8
Victorian Dwarf x Sioux	2.97	1.86	—	—	1.89	—	192	—	—
Vic. Dwarf x S.A. Dwarf	—	—	3.33	2.72	—	2.16	—	194	5.6
Vic. Dwarf x Tatinter	—	—	2.88	2.19	—	1.98	—	192	5.4

Min. diff. for sig. at 5%.
1950—Total Yield .. .. .. 1.11 lb.
First-grade Yield .. 0.92 lb.
1951—Total Yield .. .. .. 0.79 lb.
First-grade Yield .. 0.79 lb.

Mean Maturity Period—7 days Fruit Weight—0.37 ounces.

Mean Maturity Period—7 days Fruit Weight—0.32 ounces.

wilt resistant crossbreds 69 and 28 were comparatively low in both total and first-grade yields.

The best yielding F_1 hybrids for both seasons were South Australian Dwarf (M strain) x Sioux, South Australian Dwarf (C strain) x Vetomold, Tatinter x Sioux and Tatinter x Vetomold. In almost every case, the total and first-grade yields of the F_1 hybrids tended towards the highest yielding parent, but did not differ significantly from it. The relation between first-grade yields and total yields varied considerably because the larger fruited types had higher percentages of first-grade fruit than the smaller fruited ones.

Mean Maturity Period

Significant differences were obtained between the mean maturity periods given in Table II. In 1950 the earliest F_1 hybrid was South Australian Dwarf (C strain) x Vetomold, which had a mean maturity period of 187 days, but this was not significantly earlier than South Australian Dwarf (M strain) with 189 days. In 1951 two F_1 hybrids, South Australian Dwarf (M strain) x Sioux and Tatinter x Vetomold, each with 186 days, were significantly earlier than all others except Vetomold, with 189 days. The fusarium-wilt resistant crossbreds 69 and 28 were two of the latest to ripen in both seasons.

Fruit Quality

The smoothness and globular shape of Vetomold, Sioux, 69 and 28 were dominant over the wrinkled and irregular shape of South Australian Dwarf, Tatinter and Victorian Dwarf in the different F_1 hybrids. This is shown in Figure 1 with

respect to South Australian Dwarf x Vetomold.

Disease Resistance

The ratings for resistance to leaf-mould infection (Table II) show that Vetomold with 9.8 and the two F_1 hybrids South Australian Dwarf (C strain) x Vetomold, and Tatinter x Vetomold, with ratings of 9.2 and 8.6 respectively, were outstanding. It appears that the resistance of the parent Vetomold is a dominant character in the two F_1 hybrids.

Discussion

Several agronomic characteristics are required in a variety used for production of glasshouse tomatoes. It should have an indeterminate habit of growth so that it can be pruned and trained to one stem, together with early maturity and a high yield of good quality fruit. Resistance to one or more of the common diseases is an added advantage.

The highest yielding varieties, Vetomold, Sioux and South Australian Dwarf (M strain) have contrasting characters. The first two produce round, smooth fruit, while that of South Australian Dwarf is "rough". South Australian Dwarf had the best growth habit, maintained fruit size throughout the season, and possessed the best relation between total yield and yield of first-grade fruit. Vetomold, with its smaller fruit size, was

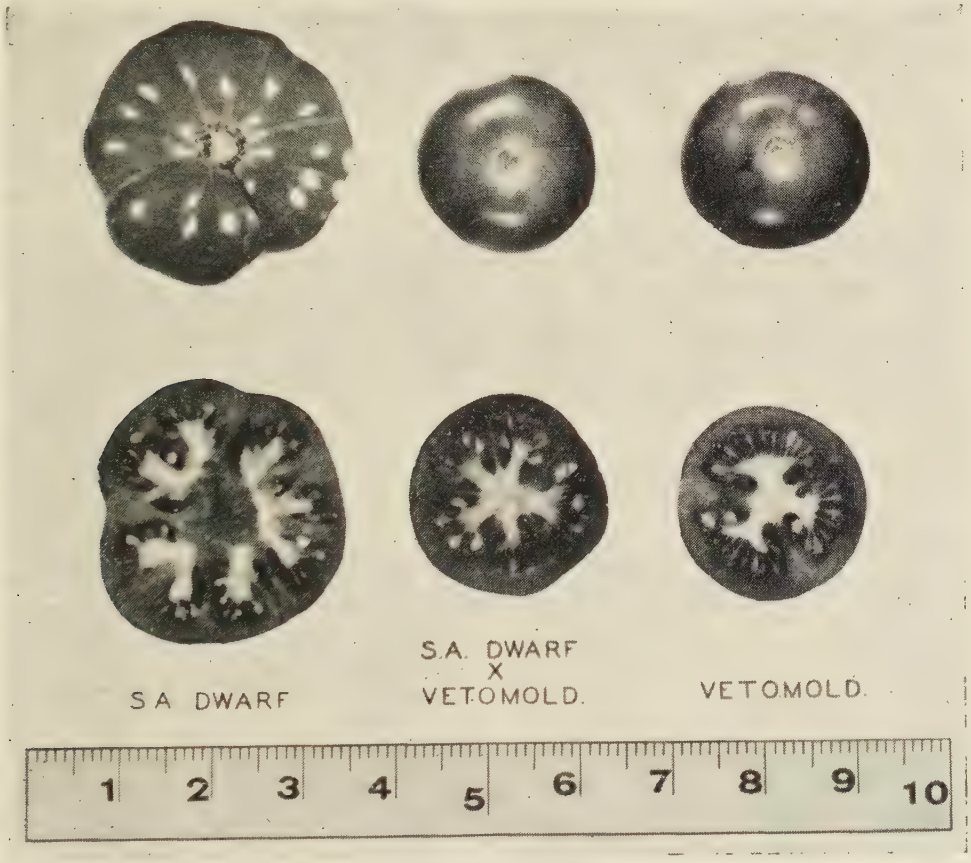

Figure 1.
Showing the smoothness, globular shape and medium to small sized fruit of Vetomold dominant over the wrinkled, large and irregular shape of South Australian Dwarf in the F_1 hybrid.

able to maintain satisfactory yields of first-grade fruit because of high total yields. This variety ripened early and had a high level of leaf-mould resistance.

There is little doubt that the desirable and complex physiological characters of these three varieties have a polygenic basis. Thus, in order to combine these characters easily the production of F_1 hybrids is warranted. These experiments have demonstrated that in the two Vetomold hybrids, namely, South Australian Dwarf (C strain) x Vetomold, and Tatinter x Vetomold, combinations of earliness, leaf-mould resistance and high yields of smooth, first-grade fruit could be obtained. The yields of the hybrids did not differ significantly from the parents so that heterosis did not accompany the combination of desirable characters.

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NON-INFECTIVE NODULE BACTERIA IN PEAT CULTURES

By J. BROCKWELL

In the course of routine examination of strains of clover nodule bacteria used for research purposes in the Division of Plant Industry, C.S.I.R.O., it was thought desirable to include a culture of commercial origin for comparative purposes. Accordingly, in October 1953 a single colony isolate was made from a plating of a commercial dry peat culture and submitted to bacteriological and plant test. This isolate proved quite unable to nodulate its host although it possessed all the cultural characteristics of *Rhizobium trifolii* Dang.

Changes in the symbiotic properties of nodule bacteria are known to occur sporadically at very low frequency under normal conditions of laboratory culture (Almon and Baldwin, 1933), and more often when conditions are unfavourable (Nutman, 1945; Kleczkowska, 1953). It is probable that the non-infective colony isolated from the peat culture was an avirulent variant of the original strain and it is clearly of importance to determine whether this particular change to avirulence represented an isolated occurrence.

Over a period of six months eleven peat culture inoculants for subterranean clover representing five brands were obtained from a number of distributors and plated on a yeast water mannitol agar medium. The plates were incubated at 25°C until recognisable colonies of nodule bacteria appeared. Two methods were used to determine the proportion of virulent bacteria present: (1) Individual colonies were used directly to inoculate clover plants grown aseptically in test tubes on an agar medium. (2) Instead of picking individual colonies the whole surface growth from each of a series of dilution plates was used to mass inoculate a similar set of plant cultures. The second method was employed so that an estimate could be made of the number of virulent bacteria in a mixture which might contain a great majority of the avirulent form, and thus fail to give a positive test using individual colonies. The validity of the second method was confirmed by inoculating plant cultures with known mixtures of virulent and avirulent bacteria. It has also been shown by Purchase (1953) that avirulent bacteria in great excess do not prevent nodulation in a mixture containing the infective form. The "Mount Barker" strain of subterranean clover (*Trifolium subterraneum* L.) was used as the test plant. Sterile seeds were inoculated with dilutions of the various culture preparations and after 100 days the inoculated plants were examined for effective nitrogen fixation.

Tables I and II show the results obtained using respectively the single colony and mass inoculation methods and include information on the age of the samples when tested. The results in Table II are presented in terms of the highest dilution that caused nodulation and the first subsequent dilution in which virulent nodule bacteria were absent. The results in Tables I and II are in concordance and indicate a preponderance of avirulent forms among the *Rhizobium*-type colonies examined. Only one peat culture was wholly satisfactory. In all cases where nodulation occurred effective symbioses followed.

Opportunity was taken with five of the peat cultures to make a total count of the

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TABLE I

Number of Individual Rh. trifolii*-type Colonies Capable of Infecting Clover Plants*

Sample No.	Age (months)	Date tested	No. of colonies tested	No. of colonies giving nodulation
1	4	15.12.53	7	0
2	4	15.12.53	7	0
3	4	15.12.53	7	0
4	4	24. 5.54	60	33
5	$2\frac{1}{2}$	24. 5.54	60	0
6	$1\frac{1}{2}$	24. 5.54	15	15
7	3	15. 6.54	23	0
8	1	15. 6.54	18	0
9	3	15. 6.54	22	7
11	$2\frac{1}{2}$	15. 6.54	9	7
Control*	7 days	15.12.53	13	13
Control*	7 days	24. 5.54	65	65

* Agar culture of clover strain 297 (Vincent & Waters, 1954)

Rhizobium-type colonies present per gram and from this to make an estimate of the probable number of bacteria which would be present on each inoculated seed. Each sample showed some degree of contamination, the amount and character differing markedly between samples (Table III). The results also suggest that the numbers of nodule bacteria fall off rapidly with the age of the culture. The conditions of storage of the cultures are likely to affect contamination and viability; these are not known.

Samples 6, 8 and 11 were also tested using Harris' modification (personal communication) of Lorenz (1941) method in which a direct dilution of the peat culture was made without plating. One ml. aliquots were taken from each five-fold dilution and the number of virulent bacteria estimated from the presence or absence of nodulation. By this method samples 6 and 11 gave a virulent count of 28×10^7 and 3×10^7 per gram respectively and therefore may be regarded as satisfactory. These results confirm the high proportion of virulent bacteria shown to be present in these samples by direct count (Table I) although the plate count of sample 11 (Table II) was somewhat lower than the figure given by Harris' method.

Sample 8 was shown to contain a very low number of virulent bacteria by both methods. Less than 1×10^4 *Rhizobium trifolii* per gram were present according to Harris' method and this result was confirmed in a direct count of the 15×10^6 *Rhizobium*-type organisms found per gram by plate count where none of 18 random colonies tested was virulent.

Discussion

It is clear from these results that the dry peat inoculants at present available may be unsatisfactory on the grounds of paucity in numbers of infective bacteria and in the presence of undesirable contaminants, faults which may arise in preparation or during storage. It should however be noted that most of the samples were rather older than they normally would be when used, although their ages were within the limits set by the manufacturers. Although it is possible that under very favourable conditions of soil moisture and fertility and with the use of liberal

TABLE II.

Number of Virulent Colonies Determined by Mass Inoculation of Plant Cultures from Plate Washings.

(Only Those Dilutions which give an "End-Point" are shown in the Table).*

Sample No.	Age (months)	Dilution	Approx. No. *Rh.-trifolii*-type colonies†	Presence or absence of nodulation
1	4	10^{6}	200	+
		10^{7}	20	−
	6	10^{6}	800	+
		$10^{-6} \times 2^{-1}$	400	−
2	4	10^{-6}	200	+
		10^{-7}	20	−
	6	$10^{-7} \times 2^{-1}$	40	+
		$10^{-7} \times 2^{-2}$	20	−
3	4	10^{-5}	4000	+
		10^{-6}	400	−
	6	10^{-7}	50	+
		$10^{-7} \times 2^{-1}$	25	−
4	4	10^{-3}	‡	+
		10^{-4}	‡	−
5	$2\frac{1}{2}$	10^{-1}	‡	no nodulation at any dilution
6	1	10^{-4}§	‡	+
7	3	10^{-2}	500	+
		10^{-3}	50	−
9	3	10^{-3}§	20	+
10	$4\frac{1}{2}$	10^{-4}§	‡	+
11	$2\frac{1}{2}$	10^{-4}§	8	+

* The "10^{-1}" dilution obtained by adding a standard loop of dry peat to 10 ml. dilution fluid.

† Estimates were made from the most appropriate dilution and are quoted to the nearest unit, ten, hundred or thousand colonies.

‡ Plate too crowded for accurate counting.

§ Dilution series not continued sufficiently far to give an "end-point".

amounts of dry inoculum some of the cultures tested may have been effective in nodulating their hosts, it is nevertheless of considerable importance that reliable and concentrated forms of inoculant should be available to ensure effective nodulation under less favourable conditions.

Studies in Europe and America have shown that the viability of nodule bacteria in peat culture is affected by the moisture content of the preparation (Newbould, 1951) and by its nutrient status and the preliminary sterilisation process (Hedlin and Newton, 1948). Van Schreven *et al* (1954) have also shown that the type of peat used affects the quality of the product and that the addition of lucerne meal greatly increases the *Rhizobium* population. Overseas, most satisfactory peat inoculants are of the wet type (Leonard, 1937). The dry method has such advantages over wet peat, soil or agar cultures in convenience of preparation, distribution and application to the seed, that it would be desirable to

TABLE III.

Estimated Microbiological Populations of Five Peat Cultures.

Sample No.	Age (months)	No. of *Rh. trifolii*-type colonies		Contamination		
		Per gram of peat culture	per inoculated seed	Bacterial	Fungal	Actinomycetal
7	3	5,000,000	72	very high*	none	none
8	1	15,000,000	343	high†	very high	none
9	3	2,000,000	47	high	few‡	few
10	4½	<1,000	<1	very high	few	very high
11	2½	8,000,000	202	very high	few	few

* Numbers in excess of *Rh. trifolii.*
† Numbers approximately the same as *Rh. trifolii.*
‡ Numbers considerably lower than *Rh. trifolii.*

determine whether the bacteriological hazards inherent in the dry method can be overcome.

Acknowledgment

The author is indebted to Mr. J. R. Harris, Division of Soils, C.S.I.R.O., who supplied details of his technique for the estimation of *Rhizobium* numbers in soil samples, and to Dr. P. S. Nutman for advice during the course of this work and assistance in the preparation of the manuscript.

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THE CONTROL OF THE QUALITY OF LEGUME SEED INOCULANTS

There has of recent years been a remarkable quickening of interest in the use of legume seed inoculants in this country. The increased demand has appeared to justify, and in fact virtually necessitate, the entry of private enterprise into this field. Several companies are already active and some State instrumentalities have ceased supplying cultures.

I am convinced that there is a real need for seed inoculation in many parts and believe that the drive supplied by private enterprise will be advantageous. At the same time, however, it cannot be overstressed that the proper handling of living bacterial cultures requires an awareness of certain difficulties and a willingness to take proper measures to meet them. Not only will the consumer suffer avoidable losses by failures at this point but the practice of seed inoculation will likewise be discredited. The farmer who buys an unsatisfactory culture is likely to lose more than the few shillings directly involved and may lose the whole cost of establishment or derive obviously incomplete benefit.

There can be several reasons for a culture being unsatisfactory.

(1) It may lack sufficient living rhizobia.

(2) The rhizobia may not be able to invade the legume for which the culture was purchased. This could be due to a mistake in packaging, incomplete cross invasiveness within an accepted inoculation group, or to an undetected loss of invasibility by variation in a culture that had been satisfactory.

(3) Nodules, though formed, may be ineffective in fixing nitrogen with the inoculated legume. This could be due to selection of the wrong bacterium caused by inadequate knowledge as to the specificity between host and bacterium or to a loss of fixation ability by culture variation.

(4) The rhizobia, though able to nodulate when tested as pure cultures, may be poor competitors in the field. The success of cultures in this regard can vary according to species of host, and, to some extent, according to locality.

Suggested Safeguards

In considering how these faults might be prevented, it seems fair to suggest that safeguards against points (1), (2) and (3) should be the definite responsibility of the manufacturer. As a minimum requirement he should be able to determine regularly the number of rhizobia and their nodulating and nitrogen-fixing ability. *Unless he can provide this degree of control, he should stay out of the culture business.* Point (4) is more difficult, although glasshouse tests might reasonably be expected and in any case there should be close liaison with research institutions.

Although I believe that the present suppliers of commercial cultures are anxious to maintain a satisfactory standard in their cultures, there must be some reservation about their ability to always ensure a proper degree of control over their product. Certainly tests that Mrs. Waters has conducted in this

laboratory have revealed an alarming proportion of unsatisfactory cultures.

Tests of Commercial Cultures

Counts for viable organisms having the cultural characteristics of *Rhizobium* in 25 peat cultures (3 manufacturers, 4 brands) gave numbers ranging from less than 1000 to more than 100 million per g peat. Four out of the twenty-five cultures would have failed on this score by any reasonable standard and each manufacturer had an unsatisfactory product on at least one occasion. Most of the cultures had been bought through ordinary retail channels, but all were tested within the time stated on the package. Pot and field trials corroborated the unsatisfactory grading and revealed many others that, despite their relatively high count, were unable to produce effective nodulation in the field. From Mrs. Waters' recent experience in the Lismore district, it could be stated with certainty that the use of most of the commercial cultures that were available would have thoroughly discredited the usefulness of peat preparations in that region. Laboratory prepared peat cultures used at the same time were completely satisfactory.

Suggested Standards

As a basis for consideration and discussion, I would suggest the following:—

(1) A licensing authority shall be satisfied that the manufacturer is equipped to properly maintain and produce cultures, and to check the numbers and symbiotic properties of the rhizobia.

(2) The specific legumes for which the culture is recommended shall be clearly stated on the package and the culture so used shall have been tested against each of the legumes so listed.

(3) A time limit for use shall be clearly stated together with recommended storage conditions and method of application to the seed. It will be the responsibility of the manufacturer to ensure that, provided storage conditions are observed, the number of viable and infective rhizobia shall not fall below a stated number at any time during the specified period.

(4) The product as it leaves the manufacturer shall, when applied according to his instructions, provide an average of at least 1000 rhizobia per seed, capable of providing effective nodules on any of the legumes specified for that package. At any time within the stated time limits, the number of like organisms per seed shall not be less than 100. Organisms other than rhizobia shall not exceed the number of rhizobia.

(5) If tests conducted by the Department of Agriculture, or other endorsed independent authority, show that the culture being supplied, although meeting requirement (4) is unsatisfactory for field use, steps shall be taken by the manufacturer to substitute an approved culture.

Methods of Testing

Several methods can be applied but the following seem the most convenient.

(1) *Presumptive count of viable rhizobia.*—Treat ordinary clean seed by the method recommended by the manufacturer, transfer 20 random seeds to 20 ml sterile tap water. Stopper, shake thoroughly and plate 0.1 and 1.0 ml with yeast mannitol agar. This will permit counts up to about 5000 per seed.

Similar platings from uninoculated seed will provide a control. The operator will need to have some familiarity with the cultural appearance, and range of variability, of rhizobia. If the plate reveals excessive contamination, the culture will be classed as unsatisfactory.

Note that the test is presumptive and those that appear satisfactory should as often as possible be taken to stage 2.

(2) *Confirmation of count and test of symbiotic properties.*—Pick 20 colonies each into 1 ml of sterile water and test the ability of the suspension to form an effective association with the specified legume. Small-seeded legumes can be tested readily on nitrogen-free seedling agar in 6 x $1\frac{1}{4}$ inch tubes. Uninoculated controls, 0.05% nitrate controls, and a couple of known effective strains should be put up at the same time. A minimum of three seedlings in each of two tubes is recommended for each single colony culture. Larger seeded kinds need special provision but tests in open plots will be satisfactory if air contamination can be kept to a minimum as checked by uninoculated controls.

(3) *Soil tests.*—Inoculation trials in pots and field should be undertaken when possible, at least with the most important legumes. This will safeguard against point (4) of the introduction. This kind of testing does, however, require some care and should, wherever possible, be backed up with serological typing.

In conclusion it should be emphasised that this is a most important phase in the development of the practice of seed inoculation in this country. To my mind it seems that the interests of consumer and producer alike will be best served if every possible care is taken to ensure that the cultures are able to do the job for which they are being sold, at all stages between production and use.

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TESTS OF COMMERCIAL PEAT INOCULANTS

With the changeover to commercial production of peat inoculants it seemed desirable to test representative samples. Tests have been carried out on four brands to check the quality of the inoculants available to the farmer. The packets of inoculant were purchased through retail channels and all were examined within the time stated on the package.

TABLE I.

Laboratory examination of commercial inoculants for Medicago spp.

Medicago inoculant	Date tested	Number of Rhizobia per gram of peat		Other organisms	Mean percentage of plants effectively nodulated on	
		Agar plate count	sand tube dilution count		lucerne	barrel medic
A	December, 1953	8,000,000	7,000,000	a great many actinomycetes	38	22
B	December, 1953	< 100,000	0		0	0
C	February, 1954	10,000,000	no figures	many moulds & actinomycetes	63	77
D	December, 1953	5,600,000,000	1,000,000,000		33	37

TABLE II.

Laboratory examination of commercial inoculants for clovers.

*Clover inoculant	Number of Rhizobia per gram of peat		Other organisms	Mean percentage of plants effectively nodulated on			
	Agar plate count	sand tube dilution count		red clover	white clover	crimson clover	subterranean clover
A	27,000,000	110,000,000	numerous bacteria and mould colonies			72	95
B	67,000,000	35,000	bacterial contaminants	.0	11	59	90
C_1	120,000,000	4,200	a great many actinomycetes	5	19	47	
C_2	excess contamination	6,700				57	77
D_1	28,000,000	11,000,000	a number of bacterial contaminants	33	33	88	
D_2	25,000,000	9,000,000	a number of bacterial contaminants			92	90

*All batches were tested in December 1953.

TABLE III.

Field examination of commercial inoculants for subterranean clover.

Clover inoculant	Packet	Number of Rhizobia per gram of peat Agar plate count	Mean percentage effectively nodulated plants
A	1	< 1000	6
	2	< 1000	0
	3	15,000,000	12
	4	no figures	0
B	1	7,000,000	19
	2	17,000,000	16
	3	10,000,000	33
	4	15,000,000	7
C	1	100,000	11
	2	130,000,000	88
	3	40,000,000	70
	4	120,000,000	75
D	1	4,000,000	3
	2	6,000,000	12
	3	550,000,000	11
	4	40,000,000	13
298 liquid			95
36 laboratory peat			93
uninoculated			22

Experimental

Laboratory tests consisted of viability counts for root nodule organisms by the agar plate method and sand tube dilution tests and pot tests set up at the same time using legumes stated on each packet as hosts. Another series was used in field tests as inoculum for subterranean clover. Replicated plots were sown at two sites near Lismore with laboratory strain 298 and uninoculated plots as controls.

Results

Three of the four medic inoculants were unsatisfactory in pot tests despite what appeared to be reasonable viability counts of root nodule organisms in two cases (Table I).

Table II gives similar data for inoculants tested against specified clovers. Results were generally good with subterranean, moderate to good with crimson, but unsatisfactory with red and white clovers, especially with brands B and C.

Results with the further series of inoculants purchased in February, 1954, and tested on subterranean clover at two sites near Lismore are given in Table III. All samples of brands A, B and D were unsatisfactory and brand C contained one unsatisfactory packet. Liquid culture 298 and neighbouring plots inoculated with fresh laboratory prepared peat cultures were uniformly good.

Nodulation results of the forty tests carried out can be classified as follows:—

Good—35%.

Fair—17.5%.

Poor—47.5%.

Thus it would appear that a large proportion of the inoculants would have been unsatisfactory if used by the farmer. This state of affairs should not be allowed to continue.

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PLASTIC POT LABELS

Whilst in the U.S.A. in 1948, Dr. A. T. Pugsley noted the use of plastic pot labels. On his return the author made enquiries to find the most suitable plastics available here. Perspex sheets were eventually chosen. These may be ob-obtained, opaque, and in a variety of light pastel colours, but white or yellow give clear contrasts.

Sheets of perspex 60 in. x 48 in. x $\frac{1}{8}$ in. costing approximately £8 per sheet were sand blasted on both sides, at a cost of £1, and sawn up, at a cost of £5, using a fine toothed circular saw, 12 points to the inch, at 3,500 r.p.m. or a fine toothed slitting saw cutting under a jet of water. Sheets $\frac{1}{16}$ in. thick are cheaper but the resulting labels are not so rigid or sturdy.

The label size chosen was 5 in. x $\frac{3}{4}$ in. which could, of course, be varied as needed but this size produces about 700 labels per sheet. It has been found that a single oblique cut is quite effective and is more economical for pointing the labels than the usual V point.

The labels can be written upon easily with an ordinary pencil and are cleaned for re-use with a rubber or with a cloth and sandsoap. Pencil written figures have remained clear and permanent for more than a year in pots and in the field.

The final cost per label is approximately $4\frac{3}{4}$d., which is more than for wooden labels but their durability, cleanliness, permanence and clarity makes them well worth while.

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SPECIFIC STATUS OF ROOT-KNOT NEMATODE

There is much confusion in Australia concerning the specific and generic status of root-knot nematodes. For many years all root-knot nematodes were classified as *Heterodera marioni* but in 1949 Chitwood established the priority of *Meloidogyne* Goeldi 1887 over *Heterodera* as the generic name and also created 5 species and one closely related variety within the genus. The specific name "*marioni*" has been discarded altogether in the new nomenclature. The differences between the species are morphological, chief being the perineal pattern or the arrangement of the cuticular annulations about the vulvas of mature females, and examples of this can be seen in Figure 1 (a) and (b).

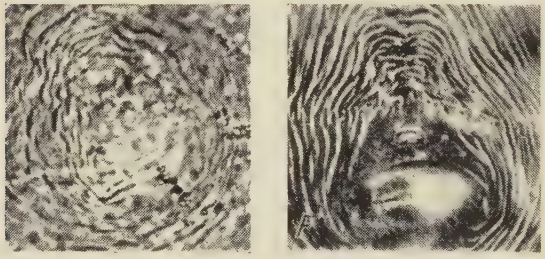

Figure 1.
(a) (b)
Phasemicrograph (x800) of (a) the perineal pattern of a mature female from Botanical Gardens, Sydney, compared with (b) M. incognita var. acrita after Chitwood.

While investigating the host-pathogen relations of *Meloidogyne* spp. at the Faculty of Agriculture, University of Sydney, an isolate obtained from the galled roots of cucumber growing in the Botanical Gardens, Sydney, was examined. Measurements of larvae and the perineal patterns of mature females agree with those given by Chitwood for *Meloidogyne incognita* var. *acrita*. Figure 1 shows the perineal pattern of a mature female from the Botanical Gardens compared with that of *M. incognita* var. *acrita* after Chitwood. No males could be found. The specific status was confirmed through the kindness of Dr. A. L. Taylor of the U.S.D.A.

Subsequent investigations show the distribution of this species to be quite widespread in the Sydney metropolitan area agreeing with its distribution in the U.S.A., where it is chiefly found in the warmer southern States. However, this is not the only species found in the metropolitan area nor is this species confined to Sydney as it has been found in other parts of New South Wales.

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pH AND DROUGHT IN RELATION TO THE DOMINANCE OF SUBTERRANEAN CLOVER OR ANNUAL MEDICS IN MALLEE AND WIMMERA SOILS

NOTES ON POT TESTS AT MELBOURNE, 1953

The search for better annual legumes for Mallee and Wimmera pastures is at present concentrated on the genus Medicago. Subterranean clover is not being studied because of the widespread belief that this plant is a failure on alkaline soils.

The main reason for this belief is ecological since the drier, more alkaline soils of New South Wales, Victoria and South Australia naturally carry annual medics and no subterranean clover. Further, where pH varies within a small area the subterranean clover is localized on the non-alkaline parts (Tiver, personal communication). It is worth noting, however, that on the calcareous alkaline soil at Walpeup Research Farm, where woolly burr medic is a volunteer species and barrel medic a promising pasture species, Dwalganup subterranean clover grew well in the wet season of 1939, but failed to regenerate the following year (Webb, 1943).

There is also a small amount of nutritional evidence which suggests that, under alkaline conditions, subterranean clover may be less efficient in the utilisation of soil nutrients than annual medics. Thus Tiver (personal communication) refers to a rendzina soil of pH 8.2 in which subterranean clover died in the seedling stage unless manured with copper, zinc and manganese, whereas medics grew normally.

There is a lack of information on the precise relation of subterranean clover to the alkaline soils of the Victorian Mallee and Wimmera, although it has been observed that subterranean clover grew well at Buchan on calcareous terrarossa soils of pH 8. Accordingly the following experiment was carried out to determine the relative growth of medics and of subterranean clover varieties of equivalent length of growing season on Mallee and Wimmera soils.

Experimental

The experiment was carried out with two medic species, namely, barrel medic (*Medicago tribuloides*) and burr medic (*M. hispida*) and with three varieties of subterranean clover (Dwalganup, Yarloop and Bacchus Marsh). The experiment was in three parts to determine:—

1. The effect of pH on germination,
2. The effect of pH and the trace elements zinc, copper and boron on relative growth in four soil types, and
3. Relative seed production with good and lowered soil moisture at flowering.

1. *Effect of pH on germination.*

Seeds were placed in petri dishes on blotting paper soaked in buffer solutions of potassium di-hydrogen phosphate at pH 4.5 and pH 8.2. Both treatments resulted in full and vigorous germination of all species.

2. *Effect of pH and the trace elements zinc, copper and boron, on the relative growth of medics and subterranean clover in four soils*

The soils were the following types, (a) Mallee sandy loam pH 8.7 (Research Station, Walpeup), (b) Wimmera black pH 9.2, (c) Wimmera red pH 8.1

(Longerenong College), and (d) a local clay loam pH 7.2 (University), a made-up soil.

At least four porcelain glazed pots were filled from each type of soil, and the following treatments applied, (1) zinc alone, (2) zinc, copper and boron, (3) normal soil, and (4) changed pH.

The trace elements were selected as those most likely to be in short supply in the Mallee and Wimmera soils. They were applied at the following rates:— zinc as hydrated zinc sulphate 10 lb/ac., copper as hydrated copper sulphate 10 lb/ac. and boron as borax 5 lb/ac.

The change of pH was directed to the acidification of the Mallee and Wimmera soils normally dominant to annual medics, and to the making alkaline of a neutral soil in which both medics and subterranean clover grow well. The alkaline soils were acidified by sulphuric acid, and the neutral soil made alkaline by calcium hydroxide. Table I shows the pH values (measured by glass electrode) of control and changed pH pots, at the beginning and end of the experiment. Superphosphate at the rate of 100 lb/ac. was applied to all pots.

TABLE I.
PH of soils in pot test, May to December, 1953.

Soil type	Treatment	pH at sowing	pH at lowering	pH at harvest
Mallee	Control	8.7		8.7
	Changed pH	6.0	6.5	7.0
	Changed pH	4.8	5.6	6.6
Wimmera Black ..	Control	9.2		9.2
	Changed pH	5.7	5.6	6.0
Wimmera Red	Control	8.1		8.1
	Changed pH	4.8	4.6	5.1
University	Control	7.2		7.2
	Changed pH	8.7	8.4	7.8

Mallee soil sown May 18, 1953; other soils May 2, 1953.

Note.—The change of pH in the Mallee and University soils over the growing period is due to the reserve of calcium carbonate in each type. In the acidified Mallee soil insoluble lumps of native calcium carbonate gradually raise pH. In the University one, immediate excess lime slowly gets neutralised by odd hydrogen ions in clay and organic matter.

The three commercial varieties of subterranean clover and two species of medic mentioned above were selected for their equivalent length of growing season. The seed was inoculated with the appropriate *Rhizobia*, and ten seeds of each of the five types sown shallowly in each pot. The pots were placed outside with adequate light and moisture. Nodule formation was normal in all varieties and soils. The earliest type Dwalganup began flowering in early September, and the others later in the month, Bacchus Marsh being the latest. On September 2, 1953, the plants in each treatment were sampled for relative growth and dry weight. Each type was then reduced to three plants per pot and four of the pots were used for the drought test.

Results

The growth of both medics and subterranean clover was healthy and vigorous in all pots ranging from pH 4.8 to 9.2. Below pH 4.5, the growth of both medics and clover was very poor. The addition of the trace elements had no effect on growth. Figure 1 shows plants of the five types grown in the Mallee soil and photographed in early September. Such growth was typical of all soils and treatments, except the most acid soils. The larger size of Yarloop was typical of its appearance in all the soils. This can be seen in Table II also, in terms of dry weight.

3. *Relative seed production with good and lowered soil moisture at flowering*

For this test pots of Mallee and Wimmera soils were selected from the above controls. A pot of Mallee soil and one of Wimmera black were sheltered from rain from early September onwards, while the controls were watered as necessary. The plants in these treatments were dry from late November, while the control ones lasted till mid-December. The number of burrs and the seeds per burr were estimated for each variety in each pot.

TABLE II.

Dry weight of plant types.
(Samples taken early September.)

Soil	pH	No. plants	Mean grams/plant				
			Medic		Subterranean clover		
			Barrel	Burr	Dwal-ganup	Yarloop	Bacchus Marsh
Mallee . ..	8.7	6	0.2		0.2	0.6	0.1
*Wimmera and University	9.2, 8.1 7.2	6 .	0.4	0.1	0.3	0.7	0.3

*Samples drawn from plants in pots of the two Wimmera soils and the University one.

TABLE III.

Effect of incidence of drought on burr production.
(Mean number of burrs per plant.)

Unwatered	Type Soil	Medic		Subterranean clover		
		Barrel	Burr	Dwalganup	Yarloop	Bacchus Marsh
From Sept 8	Mallee	7	13	1	5	1
	Wimmera Black	8	6	4	8	2
From Oct. 19	Mallee	19	30	4	16	13
	Wimmera Black	28	9	8	24	2

Mean number of burrs per plant from 3 plants per variety counted end of November, 1953.

TABLE IV.

Effect of drought on seedsetting.
(Soil type: Wimmera black.)

Number of seeds per burr.

Water Supply	Medic			Subterranean clover		
	Seeds/Burr	Barrel	Burr	Dwalganup	Yarloop	Bacchus Marsh
Normal	Mean S/B	5.5		3.1	2.9	3.0
	Range	5-7		2-4	2-3	1-4
Drought from mid-October ..	Mean S/B	5.4	3.2	2.2	3.0	2.7
	Range	4-7	2-5	1-3	2-4	1-4
Drought from September	Mean S/B	4.5	3.3	1.5	1.5	2.1
	Range	4-6	2-6	1-3	0-3	1-3

Ten burrs sampled per variety per treatment.

Dryness imposed from the beginning of flowering in September reduced the number of burrs and the seeds per burr, compared with those produced by the later treatment. Table III shows the effect of dry conditions during flowering on burr production. The mean yield of burrs from the medic species was higher than that for the three subterranean clover varieties in both treatments, but the Yarloop variety shows up as equivalent to barrel medic. Table IV shows the effect on seeds per burr. Barrel medic has higher seedsetting than burr medic and the three subterranean clover varieties.

Conclusion

Healthy germination and growth of subterranean clover varieties and the two medics over the pH range 4.8-9.2 has been shown for four soils. This suggests that there is no direct or indirect effect of high pH against the healthy growth of subterranean clover in the alkaline soils of the Mallee and the Wimmera.

These soils exist in regions liable to dry spells. It has been shown that barrel and burr medics have a higher level of seed per burr than the three subterranean clover varieties under favourable conditions. If the soil is dry at flowering, this superiority increases because of the lowering of the seedsetting in the subterranean clover varieties. The two medics also produced more burrs per plant than Dwalganup and Bacchus Marsh. Such superiority of seed production would be intensified if the comparison were between these medics and later-flowering types of subterranean clover such as Mt. Barker.

The natural occurrence of annual medics in the Mallee and Wimmera is therefore largely due to their relatively high seed production under dry conditions at flowering compared with the subterranean clover varieties sown or introduced accidentally.

The superior yield of dry matter of Yarloop to the medics, and its fair seed yield, point to the need for testing all such vigorous varieties of equivalent growing season against barrel medic in these areas.

Figure 1.
Relative growth of five types in Mallee soil of normal pH. Sown May 18, 1953, and sampled September 2, 1953.
Left: (1) Dwalganup, (2) Yarloop, (3) Bacchus Marsh.
Right: (4) Barrel Medic, (5) Burr Medic.

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ROOT-NODULE BACTERIA FOR COWPEAS ON THE RED RIVER BASALTIC SOILS OF THE RICHMOND RIVER DISTRICT OF NEW SOUTH WALES

Summary

Of three strains of root-nodule bacteria tested, only one strain obtained from C.S.I.R.O., Brisbane, ex Queensland Department of Agriculture and Stock and designated R314, was found to be efficient in effectively nodulating cowpeas (*Vigna sinensis*) grown on the red basaltic soils of the Richmond River district of New South Wales.

Introduction

In the course of extensive pasture investigations on the red basaltic soils of the Richmond River district of New South Wales, it was noticed that nearly all cowpeas sown on these soils had failed to become effectively nodulated although some of them had been inoculated with a supposedly effective strain of root-nodule bacteria.

It was decided to test the efficiency of readily available Rhizobial strains on this species grown on these soils.

Experimental

Three Rhizobial strains, each believed to be effective on cowpeas, were collected. Strains 3G5N1 and R113 came from the New South Wales Department of Agriculture, and strain R314 came from C.S.I.R.O., Brisbane, ex Queensland Department of Agriculture and Stock.

All strains were simultaneously subcultured on to standard 4 oz bottle agar slopes and eight days later these well-grown slopes were used to inoculate the cowpea seed at the rate of one 4 oz culture per 6 lb of seed.

Half-gallon open-bottomed pots, each with a diameter of 6 in. were used. All pots were nearly filled with red soil taken from Mrs. I. Boots' farm at Wollongbar near Lismore. The fertiliser used was a mixture of molybdenised superphosphate at 2 cwt per acre and dolomite at 2 cwt per acre.

At planting, 20 inoculated and shade-dried seeds were mixed with the fertiliser and spread evenly over the soil surface in the pot. The seed and fertiliser was then covered by 1 in. of red soil. All pots were watered after planting and buried in similar red soil. To prevent possible inter-pot contamination, pots were spaced 18 in. apart. Pots were planted on September 30, 1953 and four replications of each treatment were used. Plants were lifted and their nodulation assessed on November 5, 1953.

A plant was classified as carrying crown nodules if it had one or more effective nodules on the main root within 1 in. of the crown. Past experience has shown that in soils deficient in native rhizobia the crown nodules produced are almost certain to be from the strain used in seed inoculation.

Results

A summary of the nodulation assessment for each rhizobial treatment is given in Table I.

The results obtained serve to indicate the necessity for selecting Rhizobial strains not only on their capacity to form an effective association with the host plant but also on their capacity to achieve this association under the particular soil conditions to which the strain is to be subjected.

The strain R314 was tested on red soils near Lismore on a paddock scale during the summer of 1953/54 at the

TABLE I.

Nodulation Assessment.
Mean of four replications.

Rhizobial Strain	Mean percentage of plants carrying crown nodules	Mean percentage of plants effectively nodulated
3G5N1	Nil	9
R113	Nil	7
R314	67	84
Nil	Nil	9

rate of one 4 oz agar culture to 12 lb of seed and it was found to be most effective in achieving good nodulation and excellent fodder growth.

F. C. CROFTS.
Pasture Research Group,
Department of Agriculture,
Lismore,
New South Wales.

H. V. JENKINS.
Faculty of Agriculture,
University of Sydney,
Lismore,
New South Wales.

(*Received for publication September 9, 1954*).

BOOK REVIEWS—

ENGINEERING FOR AGRICULTURAL DRAINAGE

By H. B. ROE and Q. C. AYRES

(*McGraw-Hill Book Co.* 1954. $7.50.).

This is a new book in the McGraw-Hill series on agricultural engineering. It deals with a very old subject, "drainage for agricultural benefit," which was practised by ancient civilisations and has received a great deal of attention in Europe for hundreds of years. However, it is only really in this century that there has been any large scale drainage in the United States, and only in the last twenty years has the practice reached its present national importance. It is also fairly obvious after reading this book that agricultural drainage has not yet reached the same stage in the higher rainfall areas of Australia.

The authors have related their subject to recent American research in soil science, agronomy, horticulture, farm management and economics. The emphasis on soil moisture relationships greatly strengthens their treatment; and the relation of drainage to rainfall, infiltration and run-off is discussed.

All types of drains are fully dealt with; the conditions under which each should be used, their location, design, construction and maintenance and the pitfalls to be encountered are described. Drainage of irrigated lands receives only one chapter, but this is in correct perspective, as irrigated lands represent only a small proportion of the agricultural land which has been drained, or would benefit from drainage. The authors estimate that about a quarter of the agricultural land in the United States would so benefit.

There are sections dealing with various types of drain tile, and their life expectancy in different soils. The deterioration of various types of concrete tile, which seems to be the commonest material used, is of particular interest. Cost of drainage is discussed, and presumably because of the rapid changes which occur in present-day costs, estimates of man-hours and tractor hours are given wherever possible. The sections on mole drainage, and on methods of control of water weeds, both mechanical and chemical, are perhaps rather brief.

An index, a rather comprehensive bibliography and two technical appendices have been included and most chapters are illustrated by practical engineering problems. The result is a very useful textbook for general reference, on a subject which is of growing importance in this country.

A. L. TISDALL.

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POSITIONS VACANT

PUBLIC SERVICE OF SOUTH AUSTRALIA.

Applications for the position set out hereunder will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including TUESDAY, 4th JANUARY, 1955.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

The appointee may be required to contribute to the Government Superannuation Fund.

SALARIES QUOTED ARE ACTUAL AND INCLUDE COST OF LIVING ADJUSTMENTS TO DATE.

Agricultural Department.

ADVISER IN ANIMAL PRODUCTION.

Salary Range: £1,057/1,147 per annum.

Duties: Advise producers on problems of animal husbandry and production by means of addresses, field days, and demonstrations, and to prepare articles for general dissemination. Assist in the conducting of investigations into the problems associated with animal production.

Qualifications: A Diploma in Agriculture or preferably a Degree in Agricultural Science, and practical experience in animal husbandry.

PUBLIC SERVICE OF VICTORIA

POSITIONS FOR GRADUATES IN AGRICULTURAL SCIENCE

Applications addressed to the Secretary to the Public Service Board, Public Offices, Treasury Place, Melbourne, C.2. will be received up to January 26th, 1955, from persons possessing a degree in Agricultural Science, for appointment to positions in the Department of Agriculture in the following fields:—

Agricultural Extension
Agronomy
Agrostology
Animal Husbandry
Irrigated Agriculture
Horticulture
Entomology.

Salary Range (including cost of living adjustment) at present £956-£1,190.

Further details of these positions may be obtained from the Director, Department of Agriculture, Treasury Place, Melbourne, C.2.

NOTE. Persons completing their final examinations this year are invited to apply.

INSTITUTE AFFAIRS

APPOINTMENT OF MR. J. A. ROBERTS AS EXECUTIVE OFFICER TO THE INSTITUTE

MR. J. A. ROBERTS

Mr. J. A. Roberts, who has been appointed to the newly-created position of full-time Executive Officer of the Institute, commenced duty on October 1 at office quarters secured in the Australian Wool Bureau Film Unit Buildings, 226 Clarendon Street, East Melbourne. Permanent telephone arrangements have not yet been made; the registered code name for telegrams is Agricscience, Melbourne.

Mr. Roberts graduated B.Agr.Sc. from the University of Melbourne in 1939. He played lacrosse for the University and was awarded a half blue.

Soon after joining the Department of Agriculture of Victoria in April, 1940, he was seconded to Infantry Officers Training Schools as an instructor. Full-time army service occupied him from 1941 to 1946, during which he saw overseas service, was an observer with the Imperial Australia Corps in the landing at Balik Papan and attained the rank of Captain.

Returning to the Department of Agriculture, in 1946, he was responsible for investigations on maize and oil crops and latterly for extension work.

Since April, 1950, Mr. Roberts has been Honorary Secretary of the Victorian Branch of the Institute, where he has demonstrated his ability to organise and run Branch affairs.

The Institute is singularly fortunate in having as its first Executive Officer a man of known ability and one with a detailed knowledge of Institute affairs.

COUNCIL PROCEEDINGS

Since Council proceedings were last reported in these pages the Institute has taken a step of the greatest significance — the most important since its foundation. On October 1 Mr. J. A. Roberts took up his duties as Executive Officer to the Institute, his appointment is the culmina-

tion of several years of discussion, argument and development directed towards making the Institute a more positive and effective organisation.

To recapitulate the events of the last year or so, leading up to Mr. Roberts' appointment, we must go back to July, 1953, when the then President of the Institute, Dr. A. R. Callaghan, successfully approached the Minister for Commerce and Agriculture and secured the promise of financial assistance for the establishment of a Central Secretariat to advance the main objects of the Institute. The assistance was to come from the Commonwealth Extension Services Grant.

This development made it possible to think in terms of launching the Central Secretariat and so enable the Institute to become an effective body in the fields in which it is interested. Steps were taken to amend the Articles of Association and to obtain the endorsement of the Institute, so that paid officers could be employed and the Secretariat established.

For a number of constitutional reasons, it was not until the end of May, 1954, that all difficulties were overcome. The situation at that date was that the Articles of Association had been amended to enable the employment of paid staff and a referendum of Institute members had been carried, sanctioning the establishment of the Central Secretariat.

To carry out the steps made possible by these decisions a small sub-committee, consisting of Dr. I. F. Phipps (President), Dr. A. R. Callaghan (South Australia) and Mr. R. G. Downes (Victoria), was appointed. This sub-committee called for applications for the position of Executive Officer and considered the 28 applications received. Mr. J. M. Vincent, President of the N.S.W. Branch, was co-opted to the sub-committee for the interviews.

As a result of this consideration of the applicants the position was offered to, and was accepted by, Mr. J. A. Roberts. Mr. Roberts is a member of the Institute and has, for some four years past, been Honorary Secretary of the Victorian Branch.

In the meantime a formal application was made to the Department of Commerce and Agriculture for the promised grant and this resulted in the Minister giving his approval for the following sums to be granted to the Institute in the financial years shown:

1953-54, £1,000
1954-55, £3,000
1955-56, £2,000
1956-57, £1,000

A condition of the grant is that unexpended moneys may be carried forward from one financial year to the next only to the extent that they are committed by orders placed but unfulfilled at the end of the particular financial year. To meet this condition and so make use of most of the grant for 1953-54 the greater part of the office equipment for the Executive Officer and his stenographer were ordered before June 30.

At the last meeting of Council, held in Melbourne on October 6, detailed consideration was given to the conditions of employment of the Executive Officer and to the policy which he should implement. This consideration has now largely been passed to Branches and it is expected that the next few Council meetings will see policy decisions made, under which the Executive Officer will work.

Mr. Roberts has commenced his task with a three-year term of office and at a time when most members of the Institute feel that there is a job of work for him to do. He attended his first Council meeting early in October and it is fitting that the following resolution of Council, taken at that meeting, should be recorded in this journal.

"Council Commends its Selection Committee on its action in appointing Mr. J. A. Roberts as Executive Officer and expresses its confidence in his ability to carry out the duties required of him."

Membership

The membership admissions and changes recorded at the 137th and 138th Meetings of Council are listed hereunder:

Admissions to Corporate Membership

With the recommendation of the Branch Committee concerned and the favourable report of the Qualifications Committee, the following were admitted to Corporate Membership, under Article 4 (i), unless otherwise stated:

Lipsett, J., Australian Capital Territory.
Morley, F. H. W., Australian Capital Territory.
Saunders, J. C., Australian Capital Territory.
Stevens, R. (Miss), Australian Capital Territory —4(ii).
White, H. A., Australian Capital Territory.
Barrow, N. J., New South Wales.
Hartridge, F. J., New South Wales.
Kahn, M. S. M., New South Wales.
Kahn, S. A., New South Wales.
McFarlane, J. D., New South Wales.
Walker, P. H., New South Wales.
McDonald, A., Queensland—4(ii).
McPaul, J. W., Queensland—4(ii).
Rule, L. M. C., Queensland.
Saunders, G. W., Queensland.
Forrest, R. F. W., South Australia.
Sedgley, R. H., South Australia.
Yahkya, M. U., South Australia.
Fountain, P. J., Tasmania.
Inglis, I. G., Tasmania—4(ii).
Richardson, B. D., Tasmania.
Smith, L. W., Tasmania.
Stackhouse, K. M., Tasmania—4(ii).
Arundell, P., Victoria (1953).
Bamford, G. N., Victoria.
Barber, I. A., Victoria.
Brien, J. P., Victoria.
Clarkson, K. B., Victoria.
Cook, M. B. (Miss), Victoria.
Dimelow, J. B., Victoria.
Donaldson, T. W., Victoria.
Elliott, N. M., Victoria.
Geary, W. D. C., Victoria.
Hamilton, D. G., Victoria.
Leneghan, J. J. Victoria.

McGowan, A., Victoria.
Moore, N. W., Victoria.
Thomas, N. R. (*Miss*), Victoria.
Cole, K. S., Western Australia.
Churchward, M. A. (*Miss*), Western Australia.
Fisher, H. M., Western Australia.
Fry, D. J., Western Australia.
Grewar, G. R., Western Australia.
Mulcahy, M. J., Western Australia—4(ii).
Newton, K., Western Australia.
Pearse, R. A., Western Australia.
Rumich, B., Western Australia.
Silsbury, J. H., Western Australia.
Somers, M., Western Australia.

Admission to Emeritus Membership

Ward, F. E., Tasmania.

Admissions to Student Membership

With the recommendation of the Branch Committee concerned, the following were admitted to Student Membership:
Allingham, D. H. (*Miss*), New South Wales.
Bourke, T. V., New South Wales.
Bryant, W. G., New South Wales.
Burnett, B. E. (*Miss*), New South Wales.
Catley, A., New South Wales
Colless, J. M., New South Wales.
Date, R. A., New South Wales.
Finlay, D. E., New South Wales.
Hicks, F. I. L., New South Wales.
Hunt, A. W., New South Wales.
Kable, P. F., New South Wales.
Kemeny, S. M. (*Miss*), New South Wales.
Lock, H. G., New South Wales.
McDonald, D. J., New South Wales.
McDonald, M. C. (*Mrs.*), New South Wales.
McLaren, P. W., New South Wales.
Monaghan, N. J. (*Miss*), New South Wales.
Monk, D., New South Wales.
Reardon, T. F., New South Wales.
Schipp, K. R., New South Wales.
Crouch, B. R. B., Victoria.
Finlayson, P. M., Victoria.
Gardner, A. W. (*Miss*), Victoria.
Hall, B. M. (*Miss*), Victoria.
Hart, B. F., Victoria.
Jones, L. C., Victoria.
Lamp, C. A., Victoria.
Laughlin, J. C., Victoria.
Moyle, R. G., Victoria.
Sibley, G. T., Victoria.
Swindley, F. G., Victoria.
Symons, R. H., Victoria.
Asher, C. J., Western Australia.
Brisbane, P., Western Australia.
Browne, J. F. S., Western Australia.
Campion, E. J., Western Australia.
Doyle, R. J., Western Australia.
Fels, H. E., Western Australia.
Grant-Frost, D. R., Western Australia.
Hongsapan, S., Western Australia.
Newman, F. W., Western Australia.
Pavy, T., Western Australia.
Pilter, C. A. (*Miss*), Western Australia.
Playford, G., Western Australia.
Prayurasiddhi, P., Western Australia.
Purser, D. B., Western Australia.
Rojanasoonthon, S., Western Australia.
Shalders, M. J., Western Australia.
Sinnatamby, N., Western Australia.
Smetana, P., Western Australia.
Stallwood, P. L., Western Australia.
Trotman, C., Western Australia.
Wachtel, T., Western Australia.
Ward, L. E., Western Australia.
Wijeyeroon, G. P., Western Australia.

Transfers

Donald, C. M., A.C.T. to S.A.
Fisher-Pollard, J., N.S.W. to Vic.
Gillespie, J. L., N.S.W. to Vic.
Janes, B. S., N.S.W. to Vic.
McLennan, L. W., N.S.W. to A.C.T.
Waring, H. D., N.S.W. to A.C.T.
Burns, S. G., Qld. to N.S.W.
Paul, R. A., Qld. to Tas.
Ritson, J. B., Qld. to W.A.
Bouma, D., S.A. to N.S.W.
Groenewegen, H., S.A. to N.S.W.
Ryan, J. W., S.A. to Qld.
Thompson, D. S., Tas. to N.S.W.
McIntyre, A. J., Vic. to N.S.W.
Brown, R. H., Vic. to W.A.
Chapman, A. L., Vic. to W.A.
De Beaux, S. A., W.A. to Vic.
Wolfe, J. R. M., W.A. to Qld.

Subscription Waived

On the recommendation of the Branch Committees concerned, the subscriptions of the following members were waived for the years indicated:
Brock, R. D., Australian Capital Territory, 1953.
Carne, P. B., Australian Capital Territory, 1953.
Grogan, F. O., Australian Capital Territory, 1954.
Lewis, J. N., Australian Capital Territory, 1952-53.
Christian, J., New South Wales, 1954-55.
Davey, B., New South Wales, 1954-55.
Donovan, K., New South Wales, 1954-55.
Valder, P. J., New South Wales, 1954-55.
Acock, A. M., Victoria, 1954.
Edwards, C. E. (*Miss*), Victoria, 1952-53.
Erlich, S., Victoria, 1954.
Gorman, P. P., Victoria, 1952-53-54.
Gurnett-Smith, A. F., Victoria, 1954.
Hackwell, A. B., Victoria, 1954.
Hedding, R. R., Victoria, 1954.
Ives, W., Victoria, 1954.
King, F. E., Victoria, 1954.
van Baer, R. A., Victoria, 1953.
Walsh, J. C., Victoria, 1954.
Rowley, S. (*Miss*), Western Australia, 1954.

Resignations

On the recommendation of the Branches concerned, the following resignations were accepted with regret:
Lewis, J. N., Australian Capital Territory.
White, L., Australian Capital Territory.
Barker, J. S. F., Student Member, N.S.W.
Carn, K. G., New South Wales.
Roark, B. A., South Australia.
Hall, I. D., Victoria.
McLennan, E., Victoria.

Terminations

The following Student Memberships in the Western Australian Branch were terminated:

Adamson, J. R.
Anderson, A. C.
Bean, M. P.
Cleeve, L. M. (Miss)
Fisher, H. M.
Grewar, G. R.
Hehir, A. F.
Lewis, J. W.
McRae, D. J.
Padgham, C. N. (Miss)
Smith, R. D.
Snow, M. M. (Miss)
Stewart, J. (Miss)
Whitely, K. T.

BRANCH NOTES

Australian Capital Territory

At a general meeting on 16th September, Dr. E. Phillis spoke on "Agricultural development in Northern Australia."

Dr. Phillis emphasised that two major factors influence potential agricultural development in North Australia. The first of these is the extent of rainfall, and the second topography. Rainfall is dependent on the N.W. monsoon which sets in towards the end of the year and lasts for 3 to 5 months. It is highest on the coast of Arnhem Land, and falls off as one proceeds S.S.E. There is a belt of land between the rough broken country in the Kimberleys and Arnhem Land, and the low rainfall zones to the south which, from the point of view of topography and rainfall, could have agricultural possibilities.

Statistical estimates of agricultural possibilities based on rainfall and evaporation data have tended to give over-optimistic estimates of these possibilities. They have not taken into account the very high temperature which marks the coming of the monsoon, and the extent to which the soil is dried out during the dry season, nor the very low available water holding capacities of N. Australian soils in general. It was pointed out that light rains on a dry soil are soon evaporated and that they can do great harm by stimulating plant growth—which then finds itself in a soil with no further available water. The impact of these conditions on seedling establishment were discussed, and it was pointed out that whilst deep planting may be of aid, in establishing the bigger seeds which can stand this treatment, there is no known technique of ensuring the establishment of smaller seeds such as grasses.

The limitations of N. Australian soils from the point of view of water instability were discussed, and the results of an experiment on land preparation which gave appreciable increases in crops was described. The basic principle appears to be to keep clod size sufficiently big and the surface sufficiently porous so that soil masses never get saturated with water and so do not slake and run together.

All soils so far examined show a marked requirement for added phosphate under cultivation. There is an unexplained story with rice at the Kimberley Station, where it would appear that virgin land has ample phosphate for rice, whereas during continued cultivation, the need for added phosphate rises markedly. Once the initial phosphate supply has been assured, nitrogen normally limits growth. In the case of tobacco and cotton, however, there appears to be a tremendous build up of nitrogen in the soil cropping, which may render the crop valueless. This is in marked contrast to the behaviour under pasture and perennial fodder crops, where the nitrogen supply appears to be reduced as the crops progress, leading to marked nitrogen starvation.

Under irrigation, sugar cane, rice and safflower have all done well at the Kimberley Research Station and it is considered that agronomic success with these crops is such that they could justify expansion under irrigation. Dryland (rainfall) agriculture is not upon such a sound basis, however. Peanuts appear to be the most promising crop to date, followed by sorghum. Large scale cultivation of these crops is being investigated at the N.T. Administration Demonstration Farm near Katherine. Cotton, which if it grew well could be the ideal crop for the region, has given very erratic results, and it has not yet been possible to appreciate the causes underlying these variations. Even so, the average yield over a number of seasons is sufficiently promising for us to pursue cotton agronomy vigorously.

Dr. Phillis considered that the North holds considerable promise for agricultural development, but that dryland agriculture will always be subject to bigger variations than would be expected in a less extreme climate.

Mr. T. G. Campbell, who has served the Branch and the Institute for five years as Branch sub-editor, has resigned from this position. The committee accepted Mr. Campbell's resignation with regret and, after thanking him for his valuable service, appointed Mr. R. D. Brock as branch sub-editor.

New South Wales

The main business of the meeting of the Branch held on 30th July, 1954, was a very successful symposium entitled "The roles of C.S.I.R.O., University and Department of Agriculture in research and extension." There were three speakers putting the points of view of the three bodies, and their addresses were followed by prolonged and stimulating discussion. Because of the nature of the subject it was felt that the texts of the addresses should not be available for publication.

Changing trends in Australian plant introduction were discussed by Mr. W. Hartley, Principal Plant Introduction Officer of the C.S.I.R.O., at the meeting held on 31st August. Mr. Hartley introduced the subject by pointing out that Australia has long been an isolated continent with its own peculiar flora and fauna. Some plant in-

troductions may have occurred centuries ago, and there is still dispute as to the indigenous nature of various plants such as couch grass.

The second stage of deliberate introduction has continued from First Fleet days and reached a high climax in the 1880's, when almost every available crop plant was brought into the country by Government and private agencies. The next phase was one of plant adaptation by breeding and selection of specific crop varieties to suit the various regional conditions. Experience has shown that prediction of an introduction's potential is not possible. Many crop and weed plants which have become important in Australia were not so in their country of origin.

The C.S.I.R.O. Division of Plant Industry, from its inception in 1939, has been concerned with the introduction of better plants and the exclusion of weeds. Pasture plants are now receiving particular attention because they had previously been neglected and because they are of growing importance in Australian agriculture. There was a slow expansion of activities during the 1930's, when work was centred at Canberra, with a Queensland sub-station at Lawes. There has been rapid expansion since the war, and now primary plant introduction testing stations are located throughout the good rainfall areas with subsidiary stations in many of the drier areas of the continent.

Plant introduction arranged largely by correspondence with overseas workers is now giving way to plant exploration in areas which are accessible, rich in plant resources and climatically similar to Australia. C.S.I.R.O. officers in the last six years have explored Paraguay, the Mediterranean region and parts of Africa. A plant breeding programme for pasture plants is now under way and long term basic genetical work is being initiated.

Results to date of all this work have been somewhat disappointing and, as yet, no pasture introduction by C.S.I.R.O. is widely grown in Australia. This is largely because of the greater difficulty of fitting pasture plants, as opposed to crop plants, into nutritional and biotic environments or agricultural systems. As an example of the difficulties, the recently introduced *Sorghum almum* is a grass of great productivity in N.W. New South Wales under dry conditions but is a potential weed in better areas.

Another successful symposium was held at the Branch meeting on 1st October and several speakers discussed the agricultural problems of New South Wales from the point of view of their own particular interests. Mr. L. K. Kaleski, Chief Soil Conservationist of the N.S.W. Soil Conservation Service, traced the development of soil conservation since active work began just before the war. Legislation to cope with the problem was passed in 1938 and amended several times since. It contains very wide powers for works and research programmes with or without the land-holders' agreement. The Soil Conservation Service staff now totals about 400, and includes 135 qualified officers. One hundred and fifty-nine major and 370 minor demonstrations have been established since 1949 at a cost of £100,000, and a sum of £300,000 has been paid by farmers themselves under the Plant-hire Scheme. At present, 12,000 farmers are now working with the Conservation Service and taking active measures to combat erosion, and 3000 more are "coming in" each year. The Manilla area, the worst eroded area in the State, is now half way to stabilisation.

Mr. S. L. Allman, Chief Entomologist of the N.S.W. Department of Agriculture, spoke on insect pest problems and said that insect attack always reduces crop yields by an average of 10-20 per cent. Problems can be classified as routine (codlin moth, cutworm), national (grasshopper) and emergency (argentine ant in N.S.W.). Three major problems in N.S.W. are the fruit fly, black beetles and grasshoppers. A systemic insecticide such as systox or metasystox may be the eventual answer to fruit fly, and newer insecticides may be more helpful against the plague numbers of black beetle than D.D.T. and B.H.C. Excellent control measures (e.g., dieldrin at 1 oz./acre) are available for grasshoppers, but the organisation and strategy of a community control programme are the real problems.

Professor A. H. Willis, Professor of Mechanical Engineering at the N.S.W. University of Technology, dealt with problems of agricultural engineering. The first is how to obtain maximum benefit from water, in particular a cheap and effective method of irrigating **broad acres** is needed. The second is the stubble mulch problem, which is too readily solved with a box of matches. The speaker considered that blade ploughs will have a great future when a really good one is designed. The third is the problem of pasture improvement equipment. However, the biggest problem of all is "what are we going to do about agricultural engineering problems." There is no Institute of Agricultural Engineers and no training courses. An unorthodox solution to this problem seems to be needed.

Mr. C. L. Goldstone, Lecturer in Sheep Husbandry at the N.S.W. University of Technology, adopted the philosophical approach to fundamental animal production problems, in particular, the efficient utilization of grassland by the grazing animal. There is a two-fold approach of the closest adaptation of the animal to the pasture growth pattern, and of the most efficient animal to produce food. For instance, we must question that the highest producing cow is the most economical producer and decide whether highest production from pastures can be obtained under mono-grazing systems.

Mr. A. Pearson, Deputy Chief, Division of Plant Industry, N.S.W. Department of Agriculture, concluded with a review of crop, weed and pasture problems. One of the biggest problems is to get the farmer to adopt what is already known. In listing a number of important problems, Mr. Pearson stated that frost causes more damage to wheat than all the diseases put together, but little is being done about it. Serrated Tussock is the worst weed in N.S.W., infesting 1½ million acres of tableland country. In the pasture field only 5 million acres of the 30 mil-

lion arable acres in N.S.W. are sown to pastures and the problem is how are the owners of the remaining acres to grow pastures? As more is known about the use of trace elements, lime gypsum and rhizobia cultures and of adaptation of species to low rainfall areas some of the answers can be provided.

The N.S.W. Branch has set up a Recruitment Sub-Committee with Mr. J. M. Vincent as convener. Mr. D. Goodchild is proving to be a particularly active member. The immediate objective is to double the number of people entering the Faculty of Agriculture at Sydney within two years and generally to stimulate interest in agriculture and all branches of Agricultural Science as a career. Possible careers and course work in Agriculture are being publicised through secondary schools, parent groups, press and radio.

The present grave shortage of agricultural graduates, both in government service and private industry, is likely to continue for several years. About 200 agricultural graduates will be required each year for the next five years, yet Australian universities will graduate less than 70 per year for the next four years.

Queensland

At a meeting in August, members were addressed by Mr. W. J. Cartmill and Mr. J. E. Ladewig, officers of the Soil Conservation Service of the Queensland Department of Agriculture and Stock. Mr. Cartmill spoke on "Some developments in Soil Conservation Machinery." He pointed out that an important problem in soil conservation practice in Queensland, and particularly on the Darling Downs, is the maintenance of a protective mulch of vegetation on the surface of the soil during periods of intense summer rainfall. Although farmers realise the importance of protecting the soil surface and desire to retain crop stubbles for this purpose, they have in the past experienced difficulty in doing so. Farm machinery that is normally available cannot be suitably adapted to the dual task of cultivating the soil and retaining crop residues as a mulch on the soil surface.

Sub-surface tillers imported from the United States of America have been tested in Queensland, and their effectiveness in handling a heavy stubble and providing good clod formation has been demonstrated. The disadvantages were that they required a tractor of greater draught than that of the usual farm tractor, and were cumbersome and of rather limited depth range. A useful alternative is the "chisel plough" now being made in Australia. Tests with this implement in several farming districts of Queensland indicate that it permits greatly improved methods of soil husbandry and may be a very useful tool in the fight against soil erosion.

Mr. Ladewig spoke on "Development in mapping procedures for land use planning." He said that the preparation of a contour base plan is an early requirement in any soil conservation work and then discussed the various methods by which this could be done. Several systems which are much cheaper than orthodox topographic surveying utilising a theodolite were described.

In September the Branch held a meeting to which were invited representatives of the Government, the Public Service and commercial firms with agricultural and pastoral interests. Thirty-eight visitors attended. Three short talks were delivered dealing with research into agricultural problems in Queensland. Mr. C. G. Hughes discussed "Cane disease control in Queensland," Mr. C. R. von Stieglitz spoke about "Trace element research," and Mr. W. H. Shaw outlined "Pasture investigations in Queensland."

The meeting in October was arranged to take place on a Saturday at the Maroochy Experiment Station about 70 miles north of Brisbane. Incessant rain caused abandonment of the meeting.

South Australia

On August 13, "Outstanding problems in agricultural and horticultural production in South Australia" were discussed by Mr. R. L. Griffith, who recently retired from the position of Senior Agricultural Adviser of the Department of Agriculture, and Mr. D. T. Kilpatrick, Senior Horticultural Adviser.

Mr. Griffith stated that most agricultural problems are connected with pasture development and particularly with low soil nitrogen levels. After several years' development, pastures often become legume dominant. There is thus a lack of stability of pastures mainly due to the absence of a true perennial grass. Micro-elements, some of which are needed in some districts, are frequently wasted. Testing on individual pastures by dressing in strips should be used more widely. In discussing selective weedicides, he said more information was needed on rate, strength and time of application. Insect pests of pastures and the use of insecticides also need consideration. In concluding, Mr. Griffith stressed the need for close co-ordination between research and extension workers.

Mr. Kilpatrick said horticultural problems were numerous and varied, but he would confine his remarks to three problems encountered mainly in the Hills fruitgrowing areas, namely, silver leaf, cherry decline virus and the resistance of codlin moth to D.D.T.

Silver leaf is one of the worst diseases of deciduous trees in South Australia and causes large tree losses each year. The main problem is that infection can commence in unwounded wood from windborne spores often originating from its alternate hosts, willows, poplars, broom, &c., infected in inaccessible places.

There are many cherry virus diseases described overseas, and it is probable that seven of these occur in South Australia. Some of these are virulent, particularly cherry decline, which is severe in some varieties, such as some popular local seedlings. Many old varieties appear to be resistant. Nitrogen soil dressings improve tree vigour, and it appears that infected trees may be able to live with the virus. This and other viruses were illustrated.

In the Paracombe district of the Adelaide Hills, with its warmer temperatures, control of codlin moth has always been more difficult than in the deep hills areas. D.D.T. spraying commenced in 1945, gave good control until 1952-53. In 1953, in spite of eleven sprays, there was a tremendous codlin moth infestation. It is almost certain that these are D.D.T. resistant and trials will be carried out with other insecticides this season.

At a meeting on 14th September Mr. Leavitt, of the Shell Chemical Corporation, spoke on "The use of anhydrous ammonia as a nitrogenous fertiliser." He stressed the importance of the use of fertilisers in increasing production.

Before World War I, the U.S.A. depended almost entirely on Chilean sodium nitrate. Then, with the Haber-Bosch process developed in Germany during World War I, ammonium sulphate became available in larger quantities. During World War II much greater quantities of ammonia were produced than ever before, chiefly for explosives. The U.S.A. now produces four million tons of ammonia annually, much of which is used in industry, the rest in agriculture. About one-fifth of the nitrogenous fertilisers used in the U.S.A. is anhydrous ammonia, which is a little cheaper than other sources.

The development of the use of anhydrous ammonia has been pioneered by the Shell Company. It was first used in 1932 in irrigation waters. From 1932 to 1940 its use was confined to California and Arizona. Since 1940 the Shell Company's "Agricultural Ammonia Fertilisation Service" has encouraged its use on a wide scale, no longer confined to irrigation water, by supplying a service from production of ammonia to application to soil.

Work done by the Shell Company has shown that there is no danger due to excess alkalinity with the use of ammonia; that provided ammonia is injected 6 inches below the soil surface, there is inappreciable loss to the air—the ammonia is rapidly absorbed by water (1020 vols. ammonia dissolve in 1 vol. water) and is then taken up by the clay complex. Nitrifying bacteria are killed near point of injection but are stimulated a short distance away and soon recolonisation occurs. At the 6 inch depth, temperature and moisture conditions are generally suitable for nitrification.

Pre-planting applications are commonly used. Many crops may absorb nitrogen as ammonium nitrogen, especially in the early stages. The production of nitrate nitrogen in the soil follows closely the absorption of nitrate nitrogen by the crop. There is in some cases danger of root burning if the seed is sown over injected points. But it is safe to apply ammonia 8 to 10 inches from growing plants of cotton and corn, for example. The quantities of anhydrous ammonia used are generally between 50 and 100 lbs./acre.

Some mechanical difficulties associated with the use of ammonia were the development of cylinders strong enough to withstand the high pressures developed by ammonia at high temperatures; and the development of a self-sealing injector shank which could be fitted to many types of cultivating implement.

At a meeting on 8th October, two speakers from the Department of Agriculture discussed the mid-north district of South Australia. Mr. J. A. Beare, Senior Soil Conservation Research Officer, described the physiography of the area, its soils, climate and land use. The area is broadly constructed of north-south ranges with red brown earth soils on colluvial material in the valleys, and mixed red brown earths, rendzinas, &c., on the hills. Rainfall varies from 15-25 in., isohyets following topography. Soil structure and fertility have declined due principally to narrow wheat-fallow rotations. Combating erosion and checking this decline is mainly a matter of widening rotation and incorporating legumes. Land use and crop rotation must be related to soils and topography on an individual paddock basis.

Mr. A. J. K. Walker, Senior Agronomist, discussed three types of legumes for the mid-North. The only perennial legume of use is lucerne which provides useful summer greenfeed. Of the annual legume pasture species, barrel medic has been widely used and is satisfactory on alkaline soils. Where barrel medic has failed sub-clover needs trial, and on neutral to acid soil it has given good results. Snail medic gives prolific winter growth and appears to have possibilities although some experience is needed with it. Of the large seeded grain legumes peas have not been used much in the past, but their use should be explored further. The whole problem of crop rotation needs to be reconsidered.

Tasmania

At a meeting held on September 17th, the Branch was addressed by Mr. P. Scott, Senior Lecturer in Geography at the University of Tasmania. Mr. Scott spoke of "Stock Movements to Seasonal Grazing in Tasmania". To open his address Mr. Scott defined the geographical term "transmutance" as an "alternating seasonal movement from a permanently settled to a temporarily occupied area, usually involving a change of altitude and climate." Mr. Scott went on to discuss briefly such stock movements in Europe and in South Africa, and then made some detailed observations on the movements of sheep and cattle from the midlands to the central plateau in Tasmania.

A survey made in 1952-53 showed that at least 135,000 sheep and approximately 2,600 cattle were moved to the plateau, and that only 60, that is 1% of Tasmanian grazing properties, are involved in the move. The movement to the plateau takes place between mid-December and mid-January and the sheep are brought back between mid-April and the end of May, although some sheep overwinter in the warmer and more sheltered S.E. corner.

Mr. Scott pointed out that transmutance is a marginal system and that it declines with the development of agriculture. Over the last 50 years there had been a world-wide decline in

the practice. There has been a decline of 40% in Tasmania. Rabbit and kangaroo infestation and fires have contributed to a reduction in carrying capacity. Difficulty in getting shepherds has also helped. High wool prices and improved fodder conservation has had the twofold effect of making some growers keep more sheep on the home block and reduce their migrating numbers, and some to increase both home and migrating flocks.

Victoria

The Annual Dinner, which was again held at the William Angliss Food Trades School, on September 28th, retained its position as the most popular Institute function, being attended by 100 members and guests. The guest speaker was Sir Ian Clunies-Ross, who spoke on agriculture in relation to modern scientific development.

Dr. C. R. Millikan in an address entitled "Plant Research in the U.S.A. and the U.K." on October 8th to the M.U.A.S., dealt with many interesting aspects of his recent trip overseas.

Mr. J. A. Roberts has resigned as Hon. Secretary of the Branch to undertake the position of Executive Officer of the A.I.A.S. Mr. R. Kefford, Honorary Assistant Secretary, is acting as Honorary Secretary until the next election of Office Bearers.

The Branch again produced a very successful "Showtime Supplement" for the "Age" newspaper, thanks to the activity of several members.

PERSONAL NOTES

Australian Capital Territory

Mr. I. F. B. Common of the Division of Entomology, C.S.I.R.O., Canberra, has recently returned from visits to entomological institutions in the United Kingdom, Europe and North America. Mr. Common spent five months at the University of Cambridge and was an Australian delegate at the Commonwealth Entomological Conference in London.

Mr. H. A. Haantjens, who has been leading the C.S.I.R.O. Land Research and Regional Survey Section's Papua-New Guinea resources survey in the Wanigela-Cape Vogel area, paid a short visit to Dutch New Guinea at the conclusion of the survey in October for discussions with scientists of the Dutch Administration. *Dr. R. D. Hoogland,* systematic botanist of the unit accompanied Mr. Haantjens.

Mr. L. F. Myers has returned to Canberra after spending twelve months in England. While overseas Mr. Myers studied the effects of light on plant competition with Professor G. E. Blackmann at the University of Oxford.

Mr. P. Sears who is Assistant Director of the Grassland Institute, D.S.I.R., New Zealand delivered seminars to agrostologists of the Division of Plant Industry, C.S.I.R.O., on a visit to Canberra in October. Mr. Sears has now returned to New Zealand after a 14 months tour, 5 months of which were spent with F.A.O. in South American countries.

Mr. C. H. Williams of the Division of Plant Industry, C.S.I.R.O., Canberra, has left on a visit to soil science research centres in the United Kingdom and U.S.A.

Dr. M. Zaitlin has arrived in Australia from the University of California at Los Angeles to take up appointment as Research Officer with the Microbiology Department of the Division of Plant Industry, C.S.I.R.O. Dr. Zaitlin has investigated seriological properties of orchid viruses and will commence investigations into the nature of resistance to Tobacco Mosaic Virus.

Mr. J. G. Crawford is in Europe on Government business associated with overseas trade and especially to attend the G.A.T.T. Conference in Geneva.

Mr. T. H. Strong is on long-service leave from the Bureau of Agricultural Economics. He attended the World Population Conference in Rome and has served on the staff of the United Nations Training Centre on Economic Development in Cairo. He plans to visit the U.S.A. before returning to Australia.

Mr. R. A. Sherwin visited New Zealand during December to examine and report on the program of aerial top-dressing in that country.

Mr. H. C. Clark visited the U.S.A. during October and November to study marketing and price problems in the dairy industry.

Mr. F. O. Grogan returned to Canberra in November after 16 months exchange duty in the U.K. with the Ministries of Food and Agriculture.

New South Wales

Mr. J. Bunt has been selected as a member of the Antarctic exploration scientific team to be stationed at the Antarctic base which the Australian Government is establishing at Mawson. He will act as marine biologist and will serve for a term of two years, the first few months being spent in Australia.

Mr. F. Crofts has resigned from the N.S.W. Department of Agriculture and has joined the staff of the School of Agriculture of Sydney University as lecturer in Agronomy. He was formerly the Departmental agronomist at Lismore.

Queensland

Mr. P. J. Skerman, Senior Lecturer in Agriculture, University of Queensland, will be a member of the Rice Mission to Ceylon arranged under the Colombo Technical Assistance Plan. The mission will spend 6 to 8 weeks in Ceylon late in 1954 examining ways and means to increase the production of rice in that country. The leader of the Mission is Sir Robert Hutchings,

K.C.I.E. and other members are Dr. Rhind, O.B.E. and Mr. C. C. Corbett.

South Australia

Mr. J. W. Ryan has left the reporting staff of the "Chronicle" and has commenced duties as Publicity Officer, Mt. Isa Mines Ltd.

Mr. J. George, formerly of the Forest Research Station, Mt. Burr, has taken up an appointment with the C.S.I.R.O. Division of Animal Health and Production, Regional Pastoral Laboratory at Armidale.

Victoria

Mr. E. G. Pont, C.S.I.R.O. Dairy Section, has transferred to Highett from Fishermen's Bend.

Mr. G. B. Woodgate, Superintendent of Agricultural Education, retired on December 10th.

Mr. E. T. Beruldsen will take over the duties of Superintendent of Agricultural Education.

Mr. G. R. Pearce, of the Victorian Department of Agriculture, is visiting Ruakura Research Station in New Zealand to further his work on grazing efficiency of cattle.

NEWS ITEMS

Eliminating "Blackhead" in Cooked Prawns

From time to time some of the iced prawns sent to the Sydney Fish Market from various fishing ports in New South Wales have been condemned on arrival because of an unsightly, black discolouration affecting the heads and other parts of the shell and legs of the prawns. This condition, known as "blackhead", develops during a period of about a day and a half between cooking and arrival at the market.

The condition was thought to be due to spoilage by micro-organisms. Now, however, research by C.S.I.R.O. has shown that the discolouration is the result of chemical changes brought about by the action of naturally occurring tissue enzymes on one of the constituents of the blood of prawns.

A similar condition develops more rapidly and more intensely in all uncooked iced prawns.

Research has shown that "blackhead" can be avoided by making sure that the prawns reach cooking temperature rapidly and that they are then held sufficiently long at flesh temperatures of 190° to 200°F. The cooking procedure which prevents "blackhead" produces well-cooked prawns with no evidence of over cooking.

Recovery of Wool Wax

Good progress is reported in the commercial exploitation of the flotation process devised some time ago by the Division of Industrial Chemistry of the C.S.I.R.O. for the recovery of wool wax or lanolin from wool scour liquors.

The new process has many advantages over conventional centrifugal methods of lanolin recovery. An increased quantity of wax is recovered, the wax is of improved quality, and a greater variety of scour effluents can be successfully treated.

A number of wool scouring firms in Australia have now installed the flotation plant in their treatment works. One installation has been operating for some time in Victoria treating 17,000 gallons of scour liquor per day. A second unit has recently gone into production in Queensland and others are in process of construction. Overseas firms have also shown interest in the process, and a large American engineering corporation has taken up a world licence for the manufacture of the wool wax recovery plant.

The new plant is cheap to install and operate, the capital cost being between £3,000 and £4,000 fully installed. At current wool wax prices scourers handling 6,000 pounds of greasy wool per eight-hour day can profitably operate the process. With the flotation process, recoveries of 50 to 60 per cent. of the wool wax present in the scour liquors can be obtained. This compares with maximum recoveries of less than 20 per cent. by previous procedures.

Being cheap and more efficient, this new method should make feasible the recovery of large quantities of wool wax which cannot be economically treated by existing methods. It is estimated that up to 90,000 tons of lanoline are present in each year's Australian wool clip and the full exploitation of this and other by-products of the wool industry may eventually prove an important factor in favour of wool in competition with artificial fibres.

Sixth Australian Canning Convention

The Sixth Australian Canning Convention was held in Adelaide from September 20-23. It was attended by 230 delegates from all States representing canners, fruit and vegetable growers organizations, canmakers and suppliers of canning machinery, and research and extension officers serving the £35,000,000 Australian fruit and vegetable canning industry.

The industry is now much more competitive. In Britain, with the return of free marketing, Australian canned foods are starting to face stiff competition in quality, price and presentation and this set the theme of the Convention. The canners' programme, as was the growers', was primarily concerned with the economics of the industry, as about 60 per cent of the production has to be exported. The main theme of the growers' programme was the economics of the harvesting of the three major canning fruits—peaches, pears and apricots. The technologists' section comprised chemists, microbiologists, quality controllers, factory and production managers and some research workers in food science. The main theme of their discussions

was the can itself. The canning industry is completely dependent on a hermetically sealed container to protect the product against spoilage. While the tin plate can is a very successful container it is not perfect. It is subject to corrosion by the product which itself may then deteriorate so that additional protection in the form of internal lacquering of the can is often necessary. The requirements for these internal can lacquers are very rigid and much research has been done on the problem to provide suitable lacquers with, for example, a high acid or sulphur resistance to meet the requirements of particular products.

Long term planning is essential to ensure the continued prosperity of the industry. On the field side the Convention has greatly assisted the industry by setting up Canning Fruit Advisory Committees in N.S.W., Victoria and South Australia to plan the production of canning fruits for maximum returns to both grower and canner.

Control of Argentine Ants

The 6th Annual Report of the C.S.I.R.O. for the year ended 30th June, 1954, states that a satisfactory method has been developed for the control of the Argentine ant, using chlordane or dieldrin sprays.

The Argentine ant, now established in a few localities in Australia, is at present mainly a domestic nuisance but if it is not eradicated soon it could become a serious agricultural pest. If the ant invades the Murray Valley or Murrumbidgee Irrigation Areas, or the coastal belts of New South Wales and Queensland, it will cause heavy losses to producers of citrus, vines, bananas, sugar and pineapples. It can be a particularly serious problem if it infests abattoirs and food processing plants where insecticides cannot be applied.

The Argentine ant was first discovered in Australia at Melbourne, in 1939, and was originally introduced from the Americas. Western Australia is the most seriously affected State — over 30 square miles were reported as infested several years ago, including 10 square miles of market gardens and small orchards near Perth. Victoria and New South Wales each have less than five square miles at present.

To be successful, action against this pest must be organised for the whole of the affected areas through the appropriate authorities. Co-operative efforts between C.S.I.R.O. and State and local authorities in a full-scale eradication campaign are yielding promising results in Sydney. Sixty-four separate infestation areas have been discovered and barrier sprayed. Initial sprayings were made with 2 per cent. chlordane emulsion. More recently ¾ per cent. dieldrin spray has been used. Similar co-operative work is going on successfully in Western Australia.

It has been found that 2 per cent. dieldrin spray applied 2½ years ago is still killing ants invading the treated area and 1 per cent. spray is still killing ants one year after application.

International Rice Commission

Mr. C. S. Christian, Officer-in Charge of Land Research and Regional Survey Section of C.S.I.R.O. has been appointed permanent liaison officer between the Working Party on Fertilizers of the International Rice Commission and technical workers concerned with this subject in Australia. Mr. Christian attended the Fourth Meeting of the Working Party on Fertilizers in Tokyo, Japan, from October 4 to 10. Mr. W. L. Conroy, Chief of the Division of Extensions, Department of Agriculture, Stock and Fisheries, Pt. Moresby, was the other Australian delegate and he attended the Fifth Meeting of the Working Party on Rice Breeding that was held concurrently with the meeting of the Working Party on Fertilizers.

Mr. Christian and Mr. Conroy represented Australia at the Fourth Session of the International Rice Commission which followed on after the meetings of the Working Parties.

D.D.D. Manufactured in Australia

Timbrol Ltd. have announced that dichlorodiphenyl dichloroethane (or D.D.D.) is now in commercial production at their factory at Rhodes, New South Wales. As far as is known this will be the first production of D.D.D. in commercial quantities outside the dollar area.

It is expected that D.D.D. formulations will be of great benefit to Australian orchardists for controlling light brown apple moth, and it seems that the chemical will supersede the poisonous sprays which are at present used to control this pest. D.D.D. has a low toxicity to humans and is non-injurious to fruit and foliage.

School on Irrigated Pastures and Fodder Crops

Personnel from all States who are interested in irrigated pastures and fodder crops attended a School on this subject from November 9th to 17th. The School, which was organised by the Victorian Department of Agriculture, covered many different aspects of irrigation and included a tour of the irrigation areas of Victoria and New South Wales. Approximately 90 delegates attended the School. The papers read during the School have been distributed in a roneoed handbook form by the Victorian Department of Agriculture, and the full proceedings will be published later.

Commonwealth Bank Grants

Last October the Commonwealth Bank approved grants totalling £68,500 for work connected with the promotion of primary production.

Of this total Australian Universities will receive £47,800 to help to meet the cost of Agricultural and veterinary research. Other bodies receiving grants include the C.S.I.R.O. (for research on agricultural machinery); the Bread Research Institute (for cereal research); the Australian Leather Research Association and the Hide and Skin Improvement Association (for work on skin quality and curing techniques). Also the Junior Farmers' Movement received a grant to enable the Movement to take part in the International Farm Youth Exchange Project.

These grants have been made from the Bank's Rural Credit Development Fund. Half the profits of the Rural Credit Department are paid into this Fund each year for this purpose. The Fund was instituted in 1928, and the grants made since that time now total £770,000.

Genetical Society of Australia

The Genetical Society of Australia held its third meeting in Adelaide on August 23rd and 24th. Professor Catcheside and his Genetics Department were hosts to thirty interstate and overseas visitors. Papers covering a wide range of plant and animal genetics and cytology were presented.

The marked advances in genetical teaching and research in Australia are reflected by the strength and activity of this newly formed society. Since 1951 two new schools of genetical training have been established; Professor Catcheside and his group at the University of Adelaide, concentrating on plant genetics, and Dr. Rendel and his group at the University of Sydney, concentrating on animal genetics. In addition to these a new research group has been established at C.S.I.R.O., Canberra under Dr. O. H. Frankel and Dr. M. J. D. White.

The papers of these well known overseas geneticists and their students and colleagues are providing a standard of meeting comparing favourably with meetings of similar societies in U.S.A. and the U.K.

The next meeting of the society will be held in Melbourne in August, 1955. The secretary of the society is Dr. A. M. Clark, Zoology Department, University of Melbourne.

Pig Testing Station at Animal Husbandry Research Centre, Werribee

Preliminary tests are now being carried out with a newly-purchased group of sows and boars. When these tests have been completed the Station will be used for progeny testing of stud breeders' pigs, by measuring and recording the production performance of their litters.

This Pig Testing Station is the first of its kind to be establishd in Australia although many such stations are maintained in overseas countries such as Denmark.

Stud A.I. Demonstration Scheme

To test the practicability of a pure-bred A.I. scheme to cover the major dairying districts of the State, the Victorian Department of Agriculture is carrying out a pilot trial in which groups of Jersey herds in the Tongala-Stanhope and Warragul districts will be inseminated in October, November and December of this year with semen from three proven Jersey bulls held at the Animal Husbandry Research Centre, Werribee.

Vitamin A Requirements of Sheep

Vitamin A supplements can be very valuable when given to sheep in the right circumstances. However, reports indicate that graziers may be wasting time and money on Vitamin A treatment of their sheep in circumstances where it can be of no value.

C.S.I.R.O. has therefore prepared the following general recommendations, based on present knowledge, for the treatment of sheep with Vitamin A supplements.

Natural Sources of Vitamin A. — All green fodders, natural pastures, improved pastures and green-feed crops such as lucerne, oats, wheat, millet, etc., are rich in carotene (pro-Vitamin A) which is converted by the animal to Vitamin A and stored in the liver and other fat depots in the body. These reserves of Vitamin A are drawn on by the animal as the need arises and, under normal conditions, can tide over a fairly lengthy period of feeding on carotene-deficient diets.

Dry standing roughage contains relatively little carotene. Conserved fodder, such as hay, contains variable quantities. During hay-making considerable destruction of carotene can occur, and even after two or three days' exposure to the sun, 80 per cent. or more of the original carotene content of crops cut for hay may be destroyed.

When weather conditions are bad for hay-making and the material is exposed for a lengthy period before baling and stacking, further destruction of carotene will take place. Therefore, the carotene content of fodder conserved under bad conditions may be negligible. Destruction continues even after baling and stacking. Old hay which has been stored for say a year or more probably contains very little carotene.

The colour of hay is a reasonable guide to its carotene content. Freshly conserved, green, leafy hay usually contains moderate quantities. All grains and cereal by-products, with the exception of yellow maize, contain negligible quantities of carotene.

General Recommendations for Treatment of Sheep with Vitamin A Supplements.

Rams. If rams are not getting any green feed it may be advisable to dose with about one million International Units of Vitamin A 6 to 8 weeks before joining with the ewes. Rams suffering from Vitamin A deficiency may show degeneration of spermatozoa and a large decrease in sperm numbers.

Lambs. If lambs are dropped in a drought and they and their dams have to exist on dry feed—either as standing dry roughage, or as concentrates and poor-quality hay—it may be desirable to drench each lamb with approximately 500,000 International Units of Vitamin A at marking, or soon after.

Weaners. Lambs dropped and weaned during a drought may benefit from a drench of, say, 500,000 International Units of Vitamin A.

Ewes. Adult ewes are not likely to benefit from treatment with a Vitamin A supplement except under very severe conditions rarely experienced in practice. If ewes are mated whilst on dry feed, and receive no green feed throughout pregnancy, lambs may be produced which are weak or dead at birth. However, experiments have shown that the normal Vitamin A reserves of the animal appear to be adequate to suffice for one lambing. In the rather unlikely event of

re-mating and carrying through a second pregnancy on dry rations, serious losses of lambs can occur.

Dry Sheep. Mature, dry sheep should be able to survive a long drought period without Vitamin A supplements provided other nutritional conditions are satisfactory.

Dosage Rates.—Cooperative experiments carried out by C.S.I.R.O. and the N.S.W. Department of Agriculture have shown that where Vitamin A supplements have proved beneficial, administration of one large dose, in the quantities recommended above, may suffice for some months. Thus, for example, weaners approximately 9 months old at the time of treatment with 500,000 International Units of Vitamin A, have still shown the beneficial effect of this seven months later.

Form of Vitamin A Concentrates.—Experimental evidence indicates that the relative effectiveness of Vitamin A concentrates depends upon the form in which they are administered. Oils are least effective, emulsions are intermediate and water soluble preparations are the most effective. Evidence for this rests mainly on work carried out with animals other than sheep, and further investigations are being conducted by C.S.I.R.O. and the New South Wales Department of Agriculture.

Vitamin A preparations available on the market include — fish oils, emulsions of fish oils or fortified fish oils, synthetic Vitamin A crystals, and synthetic Vitamin A dispersed in a neutral carrier such as oaten flour. Water-soluble Vitamin A is an example of the last category; it is synthetic Vitamin A acetate dissolved in a solution of polyoxyethylene sorbitan laurate.

THE INSTITUTE'S CENTRAL OFFICE ADDRESS

The Central Office of the A.I.A.S. has been established at

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